APRIL 1954

Journal

VOL. 46 • NO. 4

AMERICAN WATER WORKS ASSOCIATION

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Journal

AMERICAN WATER WORKS ASSOCIATION

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April 1954

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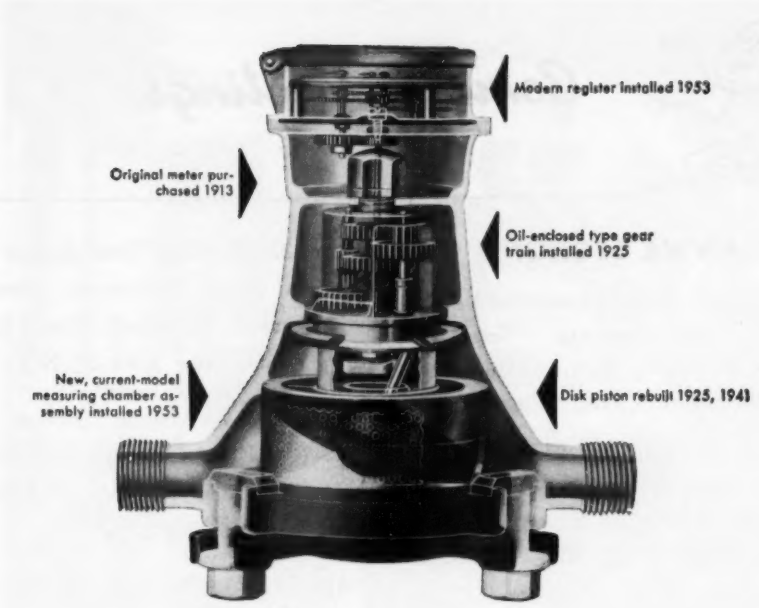
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Coming Meetings

AWWA SECTIONS

Apr. 7–9—Kansas Section at Broadview Hotel, Emporia. Secretary, Harry W. Badley, Repr., Neptune Meter Co., 119 W. Cloud, Salina, Kan.

Apr. 9—California Section at San Carlos Hotel, Monterey. Secretary, H. F. Jerauld, Supt. of Stores & Equipment, Water Dept., 1040 Manzanita Ave., Pasadena 3.

Apr. 12–14—Canadian Section at Royal York Hotel, Toronto. Secretary, A. E. Berry, Director, Ontario Dept. of Health, Parliament Bldgs., Toronto 8, Ont.

Apr. 22–23—Nebraska Section at Cornhusker Hotel, Lincoln. Secretary, E. Bruce Meier, Asst. Prof. of Civil Engineering, Univ. of Nebraska, Lincoln, Neb.

Apr. 22–23—New York Section at Woodruff Hotel, Watertown. Secretary, Kimball Blanchard, Rm. 1922, 50 W. 50 St., New York 20, N.Y.

Apr. 22–24—Arizona Section at Santa Rita Hotel, Tucson. Secretary, M. V. Ellis, Supervisor, Sewage Treatment Plant, Phoenix, Ariz.

Apr. 23–24—Montana Section at Baxter Hotel, Bozeman. Secretary, A. W. Clarkson, Acting Chief, Water Section, Div. of Environmental Sanitation, State Board of Health, Helena, Mont.

May 25—Pacific Northwest Section luncheon meeting at Norselander Cafe, Seattle, Wash. (Business meeting only; to be held during AWWA Conference May 23–28.)

AWWA ANNUAL CONFERENCE

Seattle, Wash. **May 23-28, 1954**

All reservations are being cleared through the AWWA office. The hotels have agreed to accept no reservations for the 1954 Conference except as they are requested on the standard form, through the AWWA.

(*Continued on page 8*)

Lithographed on stone for U. S. Pipe and Foundry Co. by John A. Noble, A. N. A.

THIS ILLUSTRATION shows the laying of cast iron pipe in the business section of a small town, which could be for water, gas or sewerage service. Such a situation calls for a pipe with proved long life to be placed beneath the costly permanent pavement. Whether in the business district, residential area or the country, cast iron pipe has established an enviable record of low cost per service year.

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U.S. PIPE

Coming Meetings

(Continued from page 6)

Jun. 22—New Jersey Section Summer Outing (inspection trip and luncheon) at Boonton. Secretary, C. B. Tygert, Box 178, Newark 1, N.J.

Jun. 23–25—Pennsylvania Section at Americus Hotel, Allentown. Secretary, L. S. Morgan, Div. Engr., State Dept. of Health, Greensburg, Pa.

FALL SECTION MEETINGS

Sept. 9–10—New York, in Montauk, L.I.

Sept. 15–17—Michigan, in Muskegon

Sept. 20–22—Kentucky-Tennessee, in Nashville

Sept. 22–24—Ohio, in Dayton

Sept. 26–28—Missouri, in Jefferson City

Sept. 28–30—Wisconsin, in Green Bay

Oct. 6–8—Minnesota, in St. Paul

Oct. 13–15—Iowa, in Cedar Rapids

Oct. 17–20—Southwest, in El Paso, Tex.

Oct. 24–27—Alabama-Mississippi, in Birmingham

Oct. 26–29—California, in Long Beach

Oct. 27–29—Chesapeake, in Baltimore

Nov. 3–5—Virginia, in Richmond

Nov. 4–6—New Jersey, in Atlantic City

Nov. 7–10—Florida, in St. Petersburg

Nov. 8–9—West Virginia, in Huntington

Nov. 8–10—North Carolina, in Asheville

Nov. 9–10—Rocky Mountain, in Colorado Springs

OTHER ORGANIZATIONS

Apr. 6–9—U.S.–Mexico Border Public Health Assn., in Albuquerque, N.M.

Apr. 6–7—Industry–Faculty Conference at Louisiana State Univ., Baton Rouge

Apr. 21–23—Southern Industrial Wastes Conference, at Hotel Shamrock, Houston, Tex. Sponsored by Southern Assn. of Science & Industry, Texas Chemical Council, and Manufacturing Chemists' Assn.

Apr. 22—Conference on Instrumentation in Water, Sewage, and Industrial Waste Treatment, at Manhattan College, N.Y.

May 4–6—American Public Power Assn., in Chicago

May 4–7—American Welding Society, in Buffalo, N.Y.

May 30–Jun. 5—Short School and Conference for Water and Sewage Works Operators at Univ. of Florida, Gainesville

Jun. 13–18—American Society for Testing Materials, in Chicago

Jul. 25–31—Inter-American Conference of Sanitary Engineering, in Sao Paulo, Brazil.

Aug. 3–13—Pan-American Federation of Engineering Associations (UPADI) at Sao Paulo, Brazil

Oct. 4–6—New England Water Works Assn., Poland Springs, Me.

Oct. 11–14—Federation of Sewage & Industrial Wastes Assn., in Cincinnati.

Oct. 11–15—American Public Health Assn., in Buffalo

Oct. 17–20—American Society of Civil Engineers, in New York City

Oct. 19–20—Public Utilities Sessions, National Safety Congress, Chicago

Oct. 19–22—Pennsylvania Water Works Assn., in Atlantic City, N.J.

Nov. 17–19—Water Works Management Short Course, at Univ. of Illinois, Allerton Park, Ill.

Nov. 28–Dec. 3—American Society of Mechanical Engineers, in New York

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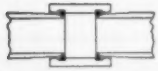
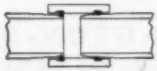
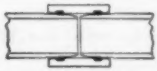


A. Rubber rings popped into grooves before assembly.



B. Lubricated pipe slides in under rubber rings.



C. Both pipes in assembled position. Rings compressed and locked in place.

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Johns-Manville TRANSITE PRESSURE PIPE

AN ASBESTOS-CEMENT PRODUCT

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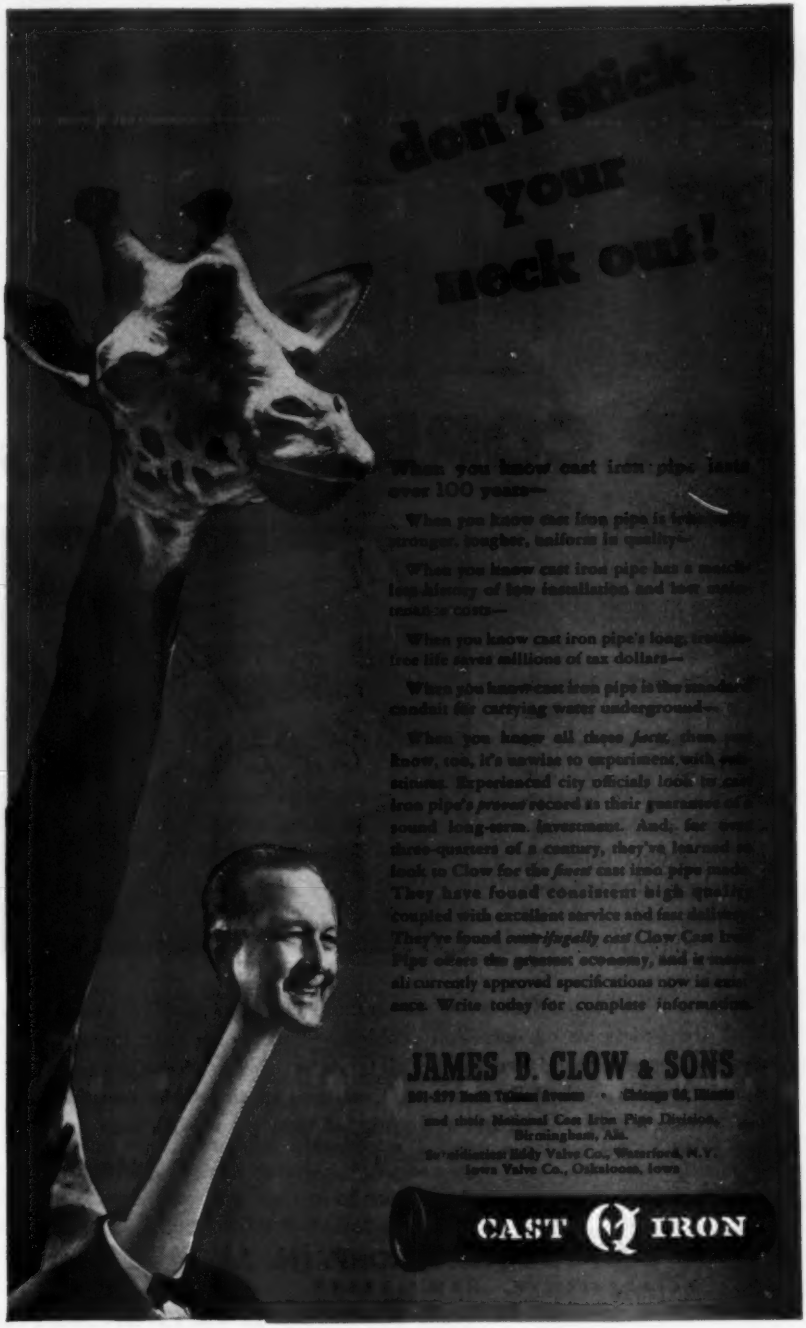
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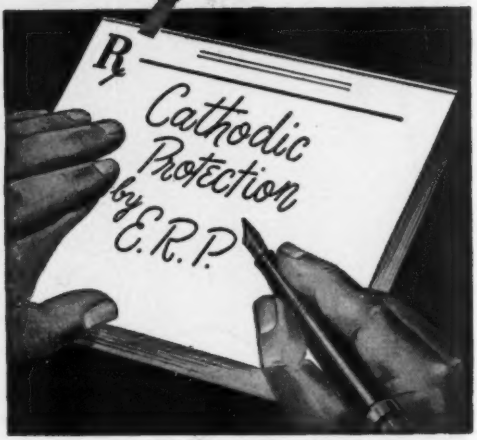
℞ FOR CORROSION...



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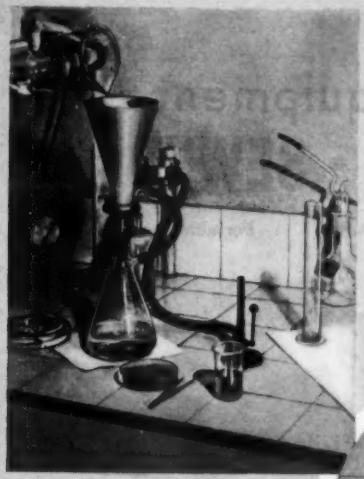

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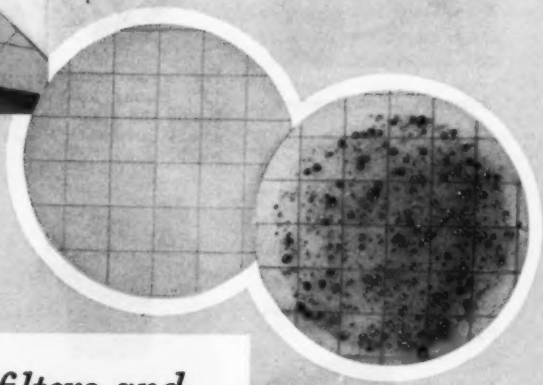
flexible membrane filter

Coli 5 Apparatus *(above)* for the filtration of bacteria, and other microorganisms



"Bac-T-Flex" is a trademark

New membrane filters and membrane filter techniques

The filters pictured above and similar membranes can be used for the determination of numbers and types of bacteria and other microbes in water, sewage, milk, foods, beverages, air and soil; for the detection and isolation of *Mycobacterium tuberculosis* from sputum or other materials; and for the filtration of fine particles from suspensions.

Membrane filter techniques save labor, time, materials and equipment. They are proving more efficient and accurate than other methods for the determination of coliform and pathogenic bacteria in water.

Write for the new free S&S Membrane Filter Folder. This folder gives detailed information and instructions regarding the use of membrane filters, including technique for sterilization, filtration, and cultivation.

Carl Schleicher & Schuell Co.

Dept. W-4 **Keene, New Hampshire**

Note these important advantages

1. **Flexible, durable, easy to handle and sterilize.**
2. **Green grid makes counting of colonies easy and accurate.**
3. **Large grid size facilitates counting using magnifications up to 15 times.**

Pipe Line Equipment
WATER • GAS • SEWER

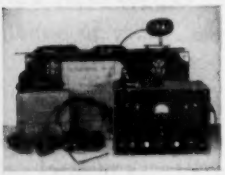
Bottled Gas Lead Melting Furnace

Asbestos Joint Runners

Best quality asbestos rope, brass caps attached to each end. Equipped with clamps.

M-D Cut-In Connections for Sewers

A light cast iron fitting with bell end for connecting house service with main sewer pipe without necessity for placing a Y-branch or T-branch in the sewer line.



Leak Detector

A truly fine instrument designed to solve even the most difficult leak detecting problem.

Calking Tool Outfit

For water mains up to 12". Strong leather bag. Keeps the right tool for every job within easy reach.

Test Plugs for Bell or Spigot End Cast Iron Pipe.

On this page are shown only a few of the hundreds of items to be found in the POLLARD Catalog. Write for a copy of Catalog No. 25K.

Portable Lead Melting Furnace

A handy outfit for quick action, equipped with gasoline burner.

Pipe Cutter

Inexpensive way of cutting pipe. Every wheel in contact with the pipe is a cutting disc, so cutter need be moved only a short distance to cut entirely around the pipe.

Tapax

The original manhole cushion. Takes the bang out of manhole covers.

M-Scope Pipe Finder

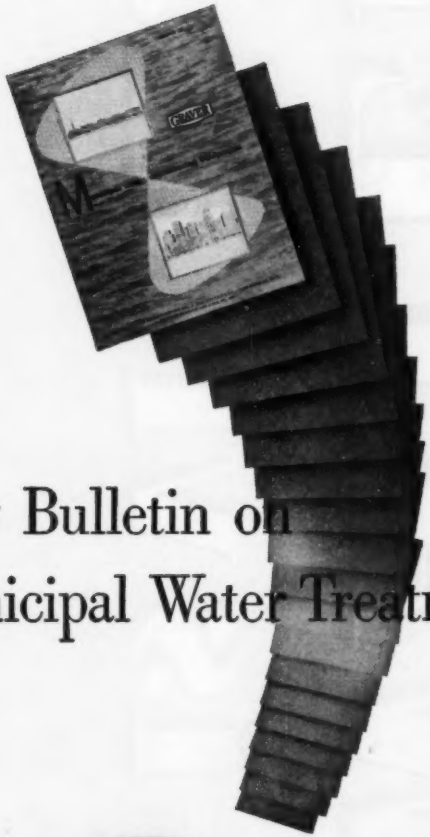
It's easy to locate a buried pipe line with this handy pipe finder.

JOSEPH G. POLLARD CO., INC.

Western Office
1064 Peoples Gas Bldg.
Chicago, Ill.

MAIN OFFICE AND FACTORY
New Hyde Park, N. Y.

Southern Office
333 Candler Bldg.
Atlanta, GA.



New Bulletin on Municipal Water Treatment

HERE'S what the bulletin contains:

1. Diagrams, pictures and explanation of the Graver Reactivator,® a self-contained, high-rate unit for the selective or simultaneous removal of turbidity, hardness, color, organic matter, taste, odor, iron and manganese.

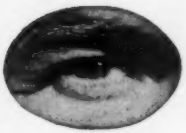
2. Description and diagrams of equipment for conventional water treatment plants. Includes flocculators, sedimentation basins, chemical feeders and mixers.

3. Description of typical package water treating plants utilizing chemical feeders and the Reactivator.

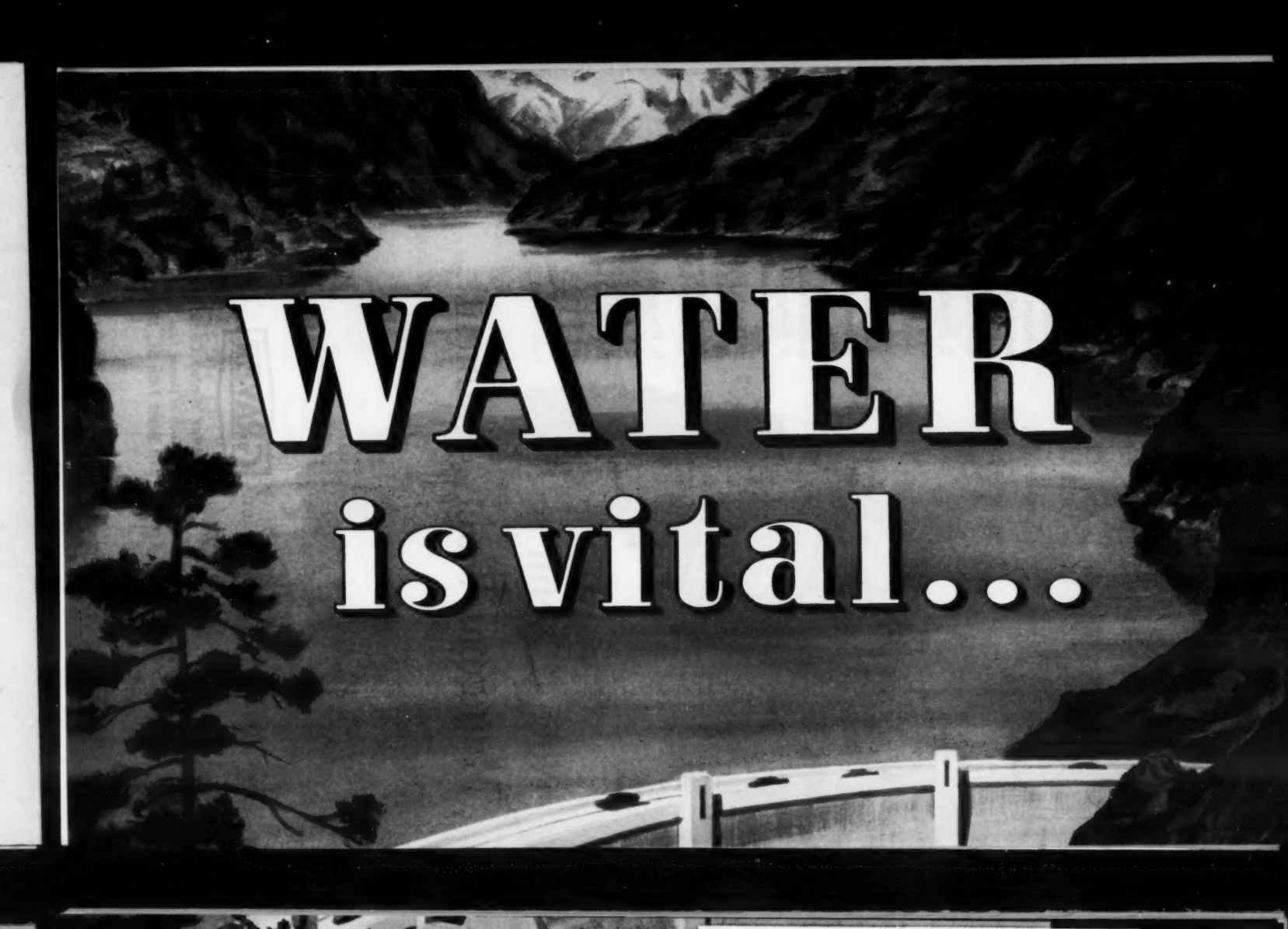
4. Details of Graver systems for iron and manganese removal, filtration, aeration and zeolite softening.

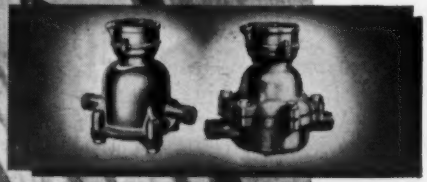
5. Discussion of water treatment equipment for swimming pools. Includes typical flow charts and equipment description.

Write for your copy of Bulletin WC-113.

Keep your  on GRAVER

Graver Water Conditioning Co.
A Division of Graver Tank & Mfg. Co., Inc.
216 West 14th St., New York 11, N. Y.


WATER
is vital...



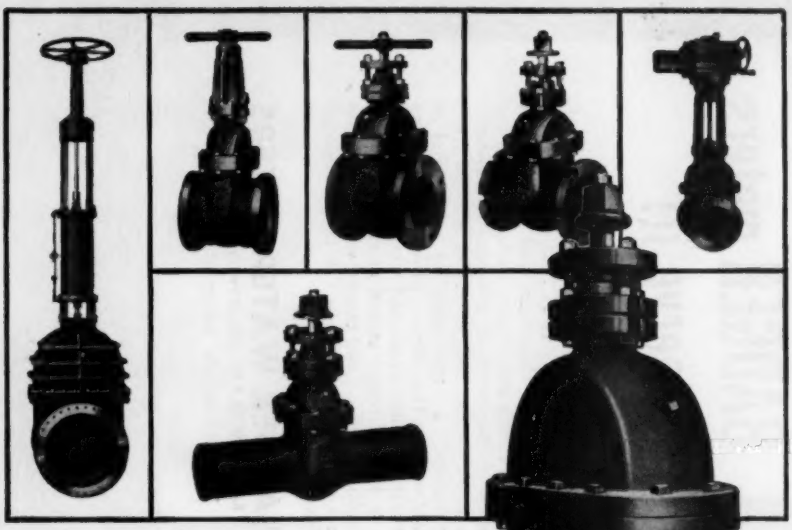
BADGER meters conserve it!

America now uses more than *7 billion gallons* of water per day . . . making conservation of supply almost as vital as the water itself. That's one reason Badger meters are used in thousands of communities throughout the nation. Badger meters measure water precisely . . . are made for every kind of water measuring job . . . provide an accurate check of water usage and water waste. And the Badger meter record of performance is unsurpassed . . . has caused waterworks men everywhere to agree — "It pays to install Badger meters!"

BADGER WATER METERS

BADGER METER MFG. CO., Milwaukee 45, Wisconsin

"Measuring the water of the world"



KENNEDY

A.W.W.A. GATE VALVES

JOB-FITTED

...for a wide range of water works requirements

KENNEDY Fig. 56, A.W.W.A. Standard Double-Disc Gate Valve

Every KENNEDY A.W.W.A. valve job is JOB-FITTED . . . specially designed and engineered for the job it has to do. Conforming to A.W.W.A. standards in every detail, these KENNEDY valves offer many extra-value features . . . one being the iron itself, which is 50% stronger than ordinary cast-iron . . . to keep them on the job year in and year out.

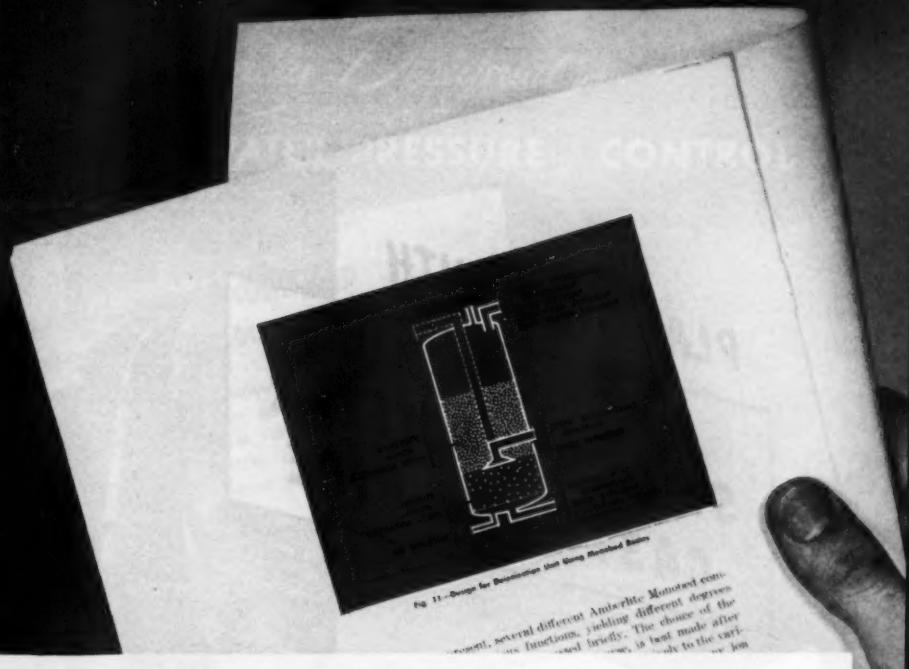
KENNEDY manufactures a most complete line of water works valves . . . in sizes from 2" to 60" . . . non-rising stem and outside-screw-and-yoke types . . . with a wide variety of gearing arrangements, controls, accessories and end connections available.

WRITE FOR BULLETIN 106

THE KENNEDY VALVE MFG. CO. • ELMIRA, N.Y.

Est. 1877

VALVES • PIPE FITTINGS • FIRE HYDRANTS



Remove All Dissolved Minerals from Water Supplies... Including Silica... at Low Cost

Two major processes are available to you for removing dissolved minerals from your water supply. One system employs multiple beds of AMBERLITE ion exchange resins; the other, a single bed—MONOBED—of AMBERLITE exchangers. Either system may be varied in many ways to suit your needs. You can remove *all* dissolved minerals. You can get water with an electrical resistance of 50,000 ohms-centimeters or 5,000,000 ohms-centimeters.

Regardless of which system you choose, you can cut costs over older evaporative methods, save time, be assured of consistently high quality water.

New Book Discusses Treatment of Water by the AMBERLITE Ion Exchange Resins

If you use water, you will be interested in obtaining a copy of *If You Use Water*, a 24-page book on the treatment of water by AMBERLITE ion exchange resins. A request to Rohm & Haas Company will bring you this publication, which contains information not only on silica removal and deionization, but on softening, dealkalization, and many other aspects of water conditioning.

Write for your free copy of this book today

CHEMICALS FOR INDUSTRY

ROHM & HAAS COMPANY

THE RESINOUS PRODUCTS DIVISION

Washington Square, Philadelphia 5, Pa.

Representatives in principal foreign countries

AMBERLITE *and* MONOBED *are trademarks, Reg. U.S. Pat. Off. and in principal foreign countries.*

ROHM & HAAS COMPANY
Washington Square, Philadelphia 5, Pa.

Please send me a copy of "If You Use Water . . ."

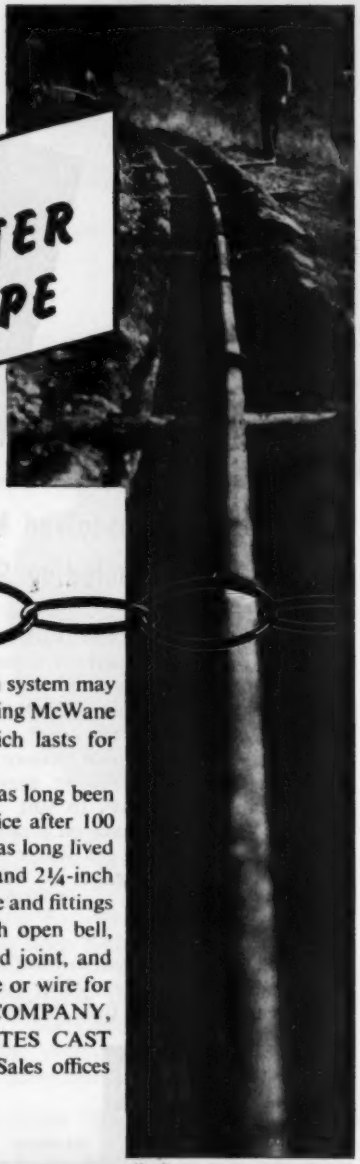
Name_____

Title_____

Address_____

City_____ State_____
(zone)

PLAY SAFE WITH McWANE-PACIFIC SMALL DIAMETER CAST IRON PIPE



The "weak link" in your water distribution system may be your small diameter pipe. Play safe by using McWane 2-inch and 2¼-inch Cast Iron Pipe—which lasts for centuries.

Cast Iron Pipe for larger water mains has long been used, many installations being still in service after 100 to 300 years. Small diameter pipe lines are as long lived as larger mains if you use McWane 2-inch and 2¼-inch Cast Iron Pipe. Small diameter cast iron pipe and fittings are available in 18-foot laying lengths with open bell, precalked bell, mechanical joint or threaded joint, and uncoated, tar coated or cement lined. Write or wire for details. McWANE CAST IRON PIPE COMPANY, Birmingham, Alabama, or PACIFIC STATES CAST IRON PIPE COMPANY, Provo, Utah. (Sales offices in principal cities.)

McWANE PACIFIC *Lasts for Centuries*

Specifically Designed

for **WATER PRESSURE CONTROL**

GOLDEN-ANDERSON CUSHIONED WATER PRESSURE REDUCING VALVE

Used to protect water lines where high initial pressures would cause serious damage to distribution mains, this very sensitive valve will maintain a uniform delivery pressure. Bulletin W-3 will interest you.

GOLDEN-ANDERSON CUSHIONED SURGE RELIEF VALVE

This valve is used to protect water lines against excessive pressures caused by surges in the system, and will open immediately when inlet pressure exceeds the adjustment of the pilot. Bulletin W-2 sent on request.

For over 50 years, Golden-Anderson has specialized in designing and manufacturing pressure control valves. The patented air and water cushioning feature effectively prevents any bang or hammer.

May our experienced engineers help you with your water pressure control problem?

GOLDEN ANDERSON *Valve Specialty Company*

1221 RIDGE AVE. • PITTSBURGH 33, PA.

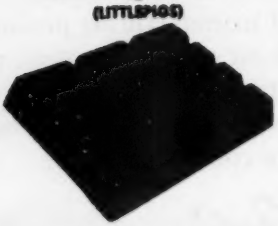
HYDRO-TITE and FIBREX

THE DEPENDABLE JOINT COMPOUND THE BACTERIA-FREE PACKING

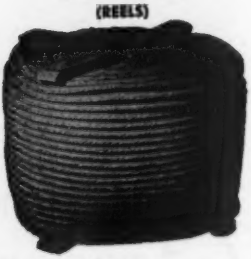
ring the bell every time with a perfect joint—

HYDRO-TITE (POWDER)

HYDRO-TITE (LITTLEPIGS)

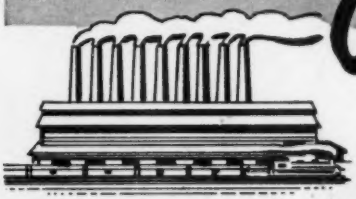


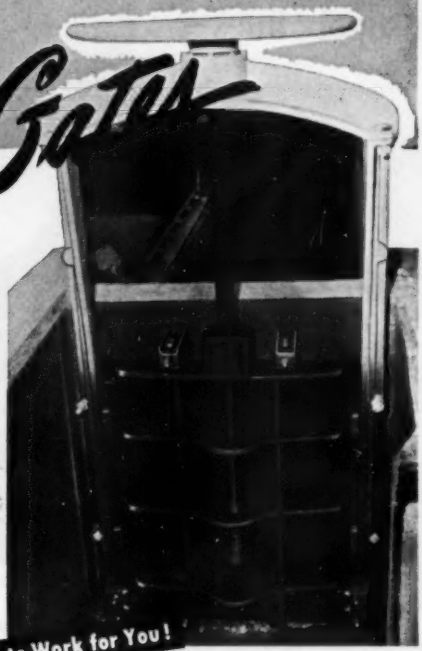
FIBREX (REELS)



HYDRAULIC DEVELOPMENT CORPORATION

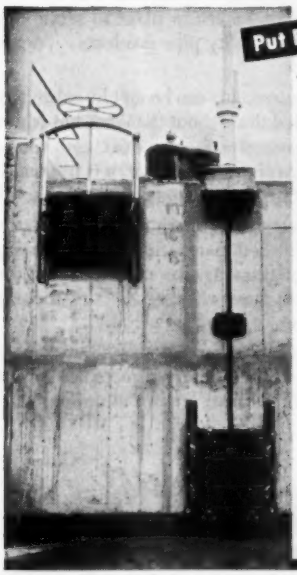
Pekrul Gates

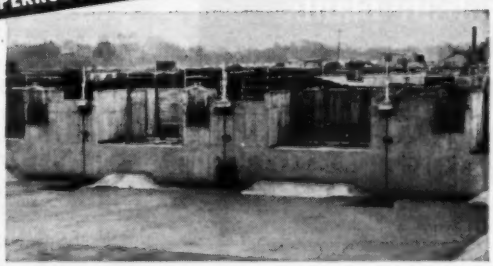




All sluice gates installed in the **United States Steel Corporation's** huge, new Fairless Works, Fairless Hills, Pa., were designed and manufactured by PEKRUL. Shown here are several gates among approximately 200 PEKRUL gates installed in pump stations and sedimentation basins.

Put PEKRUL to Work for You!





Write for Catalog 49...

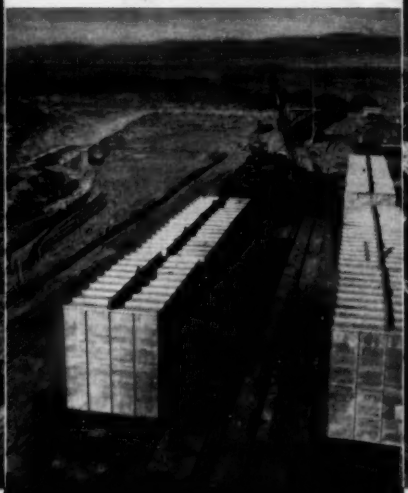
PEKRUL GATE DIVISION

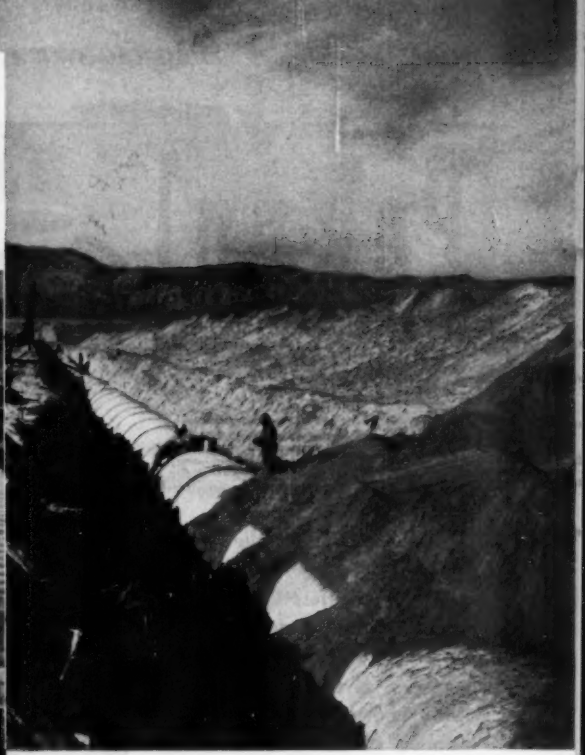
MORSE

BROS. MACHINERY

DENVER, COLORADO

In making reinforced concrete pipe for water supply lines—





permanent plants and jobsite plants put us close to any Western project

If your pipeline project is anywhere in the Western States — there is an American plant to serve you . . . equipped to supply quality pipe products . . . organized for efficient service.

Most job requirements can be met by existing plants strategically located throughout the West, but where distance and transportation factors exist and where the quantity of pipe involved is sufficient, it is frequently advantageous to set up pipe-making plants near the jobsite.

In the past few years American Pipe and Construction Co. has established many jobsite plants throughout the West. Substantial savings have been realized, for customers and manufacturer alike, by erecting these plants close to the project.

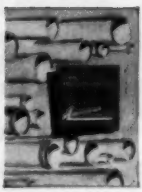
Wherever your next project is to be, we would like to help you plan it. An inquiry directed to any of our regional offices will receive prompt attention.

NOW AVAILABLE

New Bulletin No. 12

"Representative List of Installations"

. . . indicative of the wide scope of American activities. Address requests to P. O. Box 3428, Terminal Annex, Los Angeles 54, California.



American PIPE AND CONSTRUCTION CO.

Main Offices and Plant: 4635 Firestone Blvd., South Gate, California
District Sales Offices and Plants: Hayward • San Diego • Portland, Ore.
Concrete pipe for main water supply lines, storm and sanitary sewers, subaqueous pipe lines

NEW BRUNSWICK, N. J.

EQUIPS 8 FILTERS
with
POROUS UNDERDRAINS

Information courtesy
Mr. Chris C. Condon, Superintendent,
New Brunswick Water Department.

A dozen years ago New Brunswick had mushroom strainers in all their gravity filters. They also had an acute case of sand clogging. Dangerously high pressures were often needed to clear the sand. And at best, backwashing was uneven. Mudballs and upset gravel were constant problems.

In 1943, they started to modernize their filters. They installed porous underdrains, using ALOXITE® aluminum oxide plates—one filter in 1943; one in '44; two in '46, two in '48; and two in '50. Today, all their filters have ALOXITE underdrain plates, and their previous difficulties have been eliminated. Backwashing now takes five minutes and only 5000 gallons of wash water per unit, where it used to take 12 minutes and twice as much water.

Our congratulations to New Brunswick on a well planned and executed program of modernization. The low operating and maintenance costs of their porous-plate underdrains should be tremendous assets for years to come.

Send for free 56-page booklet.

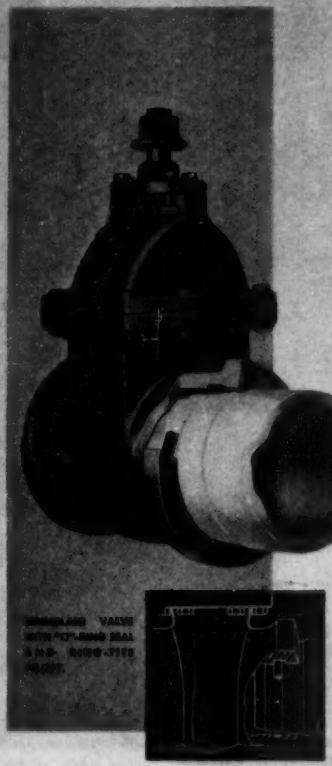
CARBORUNDUM

Registered Trade Mark

Dept. O-44, Refractories Div. The Carborundum Co. Perth Amboy, N. J.

Now Ring-Tite Joints

for RENSSELAER VALVES



Rensselaer Valve Co. in cooperation with Johns-Manville has adapted Gate Valves and Hydrants to the Ring-Tite Joint, developed by Johns-Manville for Transite Pipe. The first experimental installation of Ring-Tite valves was made in July 1953 at Mattapoisett, Massachusetts.

FAST AND SURE INSTALLATION

Rensselaer Ring-Tite Gate Valves and Fire Hydrants permit quick and simple installation with Transite Pipe. No special fittings are required and labor cost is low. Ring-Tite Bells provide tight, flexible joints.

During assembly, rings are inserted in the grooves, pipe ends are lubricated and the pipe is pulled in — sliding under the rings and slipping along until movement is stopped by shoulders on the pipe. A very simple puller is used and the job is accomplished quickly and with very little effort.

At low pressures, the seal is obtained by radial compression of rubber rings. At higher pressures, rings are wedged in the grooves tighter by the pressure.

Rensselaer Gate Valves with Ring-Tite Ends are available in sizes 4" through 12" for Class 150 Transite Pipe.

RENSSELAER GATE VALVES

Rensselaer Double Disc Parallel Seat Gate Valves are built rugged and simple, designed to give positive seating action and long life and are easy to operate, are made of high quality materials and conform to A.W.W.A. specifications. Rensselaer Gate Valves are available with "O" Ring Seals or standard packing.

Ask for Bulletins B and C.

Rensselaer VALVE CO. TROY, N. Y.

SALES REPRESENTATIVES IN PRINCIPAL CITIES

112

Builders News

B·I·F

Meters and controls engineered specifically for water, sewage, and waste plants . . . proven in thousands of installations.

INSTRUMENTATION NEWS

- Chlorinating Equipment
- Main line water meters
- Sludge and waste flow meters
- Remote metering equipment, electric, pneumatic
- Automatic, flow proportional chemical feeder control
- Filter operating tables and gauges
- Wheeler filter bottoms
- Automatic filter control
- Pump controls, automatic, supervisory
- Water level controllers, recorders

Write for detailed bulletins

Chronoflo electric telemeter for remote metering . . . saves time, saves steps

TECHNICAL NEWS

Engineering information on flow meters and controls

Industrial waste treatment guide

Add your name to our mailing list

MAINTENANCE NEWS

Nationwide service help

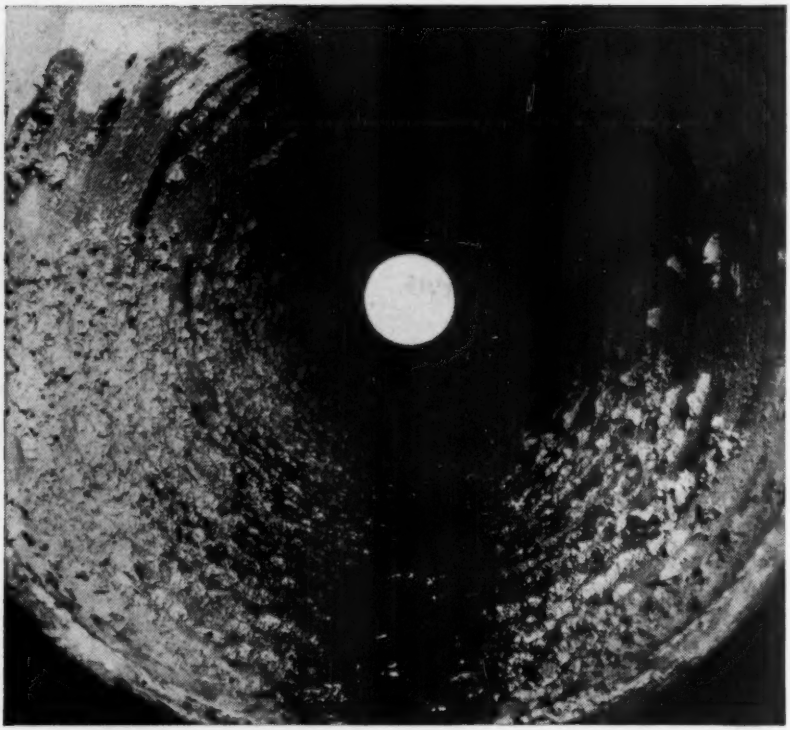
New preventive maintenance service plan —

Send for complete details

For up-to-the-minute information on the latest in meters and controls, address Builders-Providence, Inc. (Division of B-I-F Industries, Inc.), 365 Harris Ave., Providence 1, Rhode Island.

BUILDERS-PROVIDENCE

PIONEERS IN METERS AND CONTROLS



Don't let your pipeline get "TB"

Tuberculated pipe is one of many hazards which drastically reduce pipeline efficiency. Avoid this cause of capacity losses by specifying Barrett Waterworks Enamel for your pipeline operations.

Barrett Waterworks Enamel is of the highest quality, meeting all A.W.W.A. standards. When and where you use it, the services of Barrett's Service Representatives are available. These highly trained, experienced pipeline engineers assist you from the planning stage right through to the application of Barrett coal-tar enamels.

Here are the 10 special advantages of Barrett Waterworks Enamel:

• *Rigid quality control* • *Prevents tuberculation and incrustation of interior pipe surfaces* • *Effectively protects external pipe surfaces* • *High ductility and flexibility, high resistance to soil stresses* • *Unusual tenacity* • *Effective under all kinds of climatic conditions and topography* • *Quick service* • *Wide availability* • *High dielectric properties* • *Impermeable to moisture, non-absorptive, non-porous*

Barrett Division, Allied Chemical & Dye Corp., 40 Rector St., N. Y. 6, N. Y. In Canada: The Barrett Co., Ltd., 5551 St. Hubert St., Montreal.

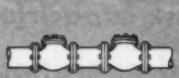
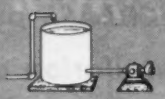
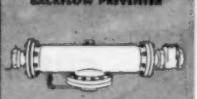
Allied Chemical

1854 1954 CENTENNIAL Barrett

BARRETT PROTECTIVE COATINGS

Comparison Chart

for water, health and plumbing officials

COMPARE	DOUBLE CHECK VALVE 	AIR GAP TANKS 	BEECO BACKFLOW PREVENTER 
Cost	Low	High	Moderate
Installation cost	Low	High	Low
Reliability (when new)	Questionable	Excellent	Excellent
Reliability (when old)	Unsatisfactory	Excellent	Excellent
Water pressure	Same	Complete loss	Slightly lower
Safety factor	Low	High	High
Acceptance	Slight	Complete	Growing
	✕	ACCEPTED	ACCEPTED

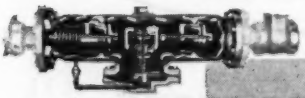
Shows the way to **MAKE CROSS CONNECTIONS Safe!**

REDUCED PRESSURE Beeco Backflow Preventers stand out as the most efficient and practical method for making cross connections safe. They give positive protection and lifetime visual proof of their efficiency. They use little space and are useful for protection not only at the water main but also within the consumers' establishment to isolate local pollution hazards. Water main pressure (paid for by the consumer) is not sacrificed with a Beeco. First cost and installation costs are very moderate as compared to the large amount of equipment required with air gap separation systems.

Since complete elimination of all cross connections is impossible as well as impractical, the Beeco Backflow Preventer offers the best method for protecting the purity of your domestic water system. Get the facts about this device which is accepted or used by many authoritative organizations as meeting the rigid specifications covering reduced pressure backflow preventer devices. Thousands of Beeco Backflow Preventers are in use in the United States. Write for complete information.

BACKFLOW ENGINEERING & EQUIPMENT COMPANY

5725 ALCOA AVENUE • LOS ANGELES 58, CALIFORNIA



It's Bonded

Reduced Pressure

BEECO BACKFLOW PREVENTER

Now There's PROOF
That REX® VERTI-FLO® will
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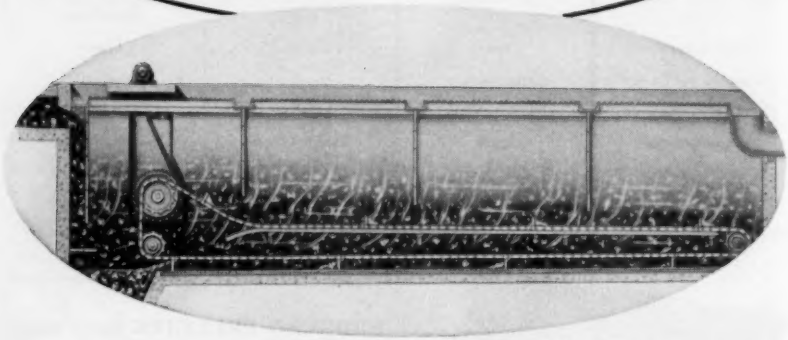

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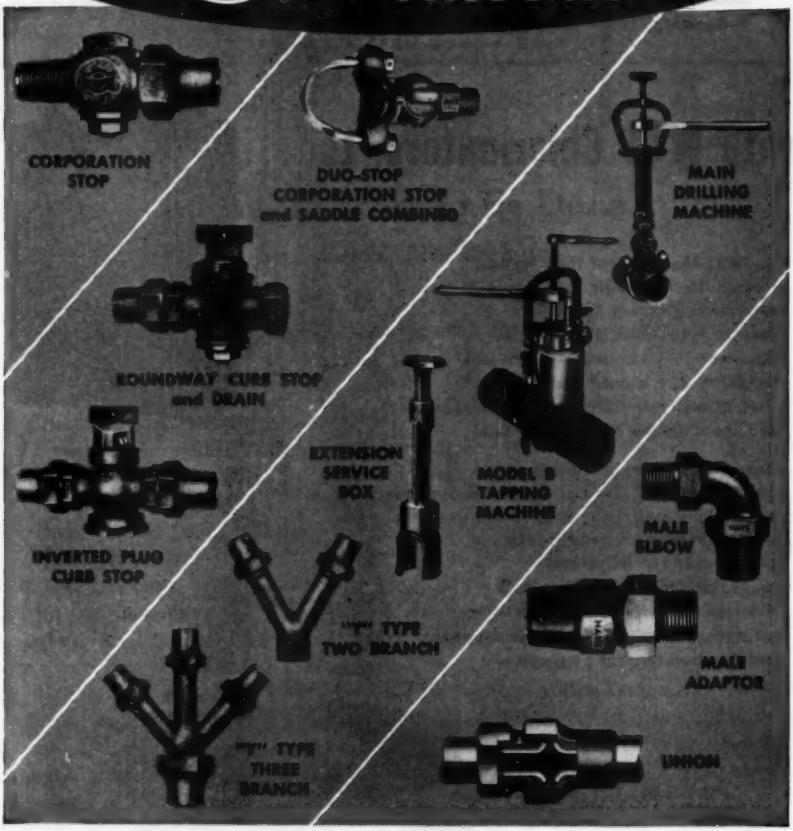

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There Is Work to Be Done

By John H. Murdoch Jr.

An address presented on Jan. 19, 1954, at the New York Section Meeting, New York City, by John H. Murdoch Jr., Vice-Pres. & Counsel, American Water Works Service Co., Philadelphia.

WATER works officials have great reason for pride in their accomplishments. Those who remember water supply and health conditions as they were 50–60 years ago can testify to such improvements as would justify each water works man in the feeling that he has had some part in creating an urban civilization reasonably safe from waterborne disease. Through the distribution of pure water under pressure, water utilities have made it possible for communities to grow in population and industry. The AWWA has played a leading part in advancing better water works practices and in bringing public water supplies to more and more people. There are certainly grounds for all of us to feel proud of our lifework.

There is a great danger, however, in this feeling of pride. We tend to become conservative to the extent that we feel that no changes in our art and no new discoveries in the science of water supply are needed. We go beyond the position that suggested changes are impossible dreams and come to the point where we believe that conditions are now so good that they need not be improved. We are in danger of getting so wrapped up in pride over past accomplishments that we become complacent and refuse to see areas in which improvements should be made. Mental stagnation and atrophy of the power to drive ahead toward ever widening horizons of worth-while public service are the inevitable result of such complacency.

There is room for improvement in public water supply service. There are places in our field for young men of imagination, courage, and skill.

Adequacy of Supply

Too many communities were faced with water supply difficulties last year. Too many had to enforce regulations forbidding all but the most essential of

water uses. In too many instances, the officials watched with anxiety as available supplies dwindled while heat and drought added to the public demand for water. Pleas for understanding, forbearance, and restraint had to be addressed to people who were watching expensive shrubbery and valuable gardens wither and die for want of water. Businesses were handicapped and suffered losses because of lack of water. Sometimes disaster was averted only by the use of unsatisfactory sources. There have been enough of such situations and some of them have recurred often enough to constitute a real challenge to us.

What is an adequate supply? Is a supply adequate if it is sufficient to meet normal summer loads in years of average rainfall but not in a drought year? If the minimum safe yield of the water supply sources is not sufficient to give the customers the water that they want when they want it, is that water supply adequate? These questions cannot be answered "yes" or "no." Assume that the supply is large enough to meet customer demands in 9 years out of every ten and that, to meet the needs of the tenth year, proportionately very large capital expenditures for additional works would be required. Many communities might well decide that the inconvenience and danger of an insufficient supply in the tenth year are far outweighed by the increased cost for the other nine. Other communities might decide just the reverse. Public opinion, formed after free discussion and with the advice of water works experts, must be counted on to give the answers. It is suggested that we need some well defined phraseology to describe the degrees to which water supply meets customer needs.

Assume now that a community has a developed supply which is fully sufficient to meet the present peak demands of customers even in periods of below-average rainfall, and that such a supply system has imposed financial strains on the enterprise or the town. Should rate inducements be held out to a prospective customer who would consume a large part of the rarely used portion of the supply that represents the margin of safety? As the incremental cost of supplying the new customer would be less than the expected revenue, the income would be a substantial contribution toward the carrying charges on the excess supply capacity. The prospective customer may be a desirable new industry enlarging employment opportunities. Yet adding the new customer will reduce the margin of safety in the supply works and again bring up the need for new capital. When the new supply is created with its added capital costs, there will again be requests to provide inducements for new customers to use part of the added supply; and so on, *ad infinitum*. Water engineers and economists have much constructive thinking to do in this field.

Pollution

Water works officials are strangely apathetic about stream pollution and industrial use of water. Both of these matters are of great concern because of their impact on water supply quality and adequacy. Community and industrial waste disposal are essential to civilized life, and our stream systems must be depended upon somewhat to act as the ultimate vehicle for most waste disposal plant effluents. Today, how-

ever, there is much needless burdening of streams with wastes. As a result, otherwise readily available sources of public water supply must be ignored and much more costly distant sources must be developed. Our influence and knowledge should be strongly on the side of sound clean-streams programs. Because of the growing difficulty of securing ample potable supplies, we should find some ways to help industry to conserve water. Our engineers and chemists could perform valuable water works service by advising industries how to avoid unnecessary and costly depletion of community supplies by circulating, processing and reusing the water entering the plant.

Population Shifts

The changing living habits of the nation present problems for water works men. Territory formerly profitable, with customers fairly closely spaced along the mains, may have become blighted areas with very few customers or may be occupied by great housing developments, taxing the capacity of the distribution system and yet getting water service at much lower cost per family unit than do homeowners using less water. On the other hand, families are moving into suburban areas. These people do not always have the choice of buying in a fully developed urban district or taking a property in undeveloped territory. The pressure of population growth often forces them to move into unimproved suburbs. These families need water and a true sewerage system. As they did not go outside the city to save money, it is questionable whether they should be discriminated against in the cost of water and sewer service. But should the remaining customers be required to bear the burden of extending new facilities at present costs into new territory, with no advantage to themselves?

Abel Wolman (*1*) has called the attention of public health officers to some disturbing conditions that present problems which water works officials—being, in a very real sense, a part of the community public health organization—should help to solve. Wolman states:

> All of us in public health and public administration have fallen down in two areas of effort. We have failed to develop the administrative and fiscal machinery necessary to provide the public amenities of water supply, sewerage, and sewage disposal in areas outside the political boundaries of individual cities. Efficient planning, with very few exceptions, declines as one moves out of the municipality itself into its [suburban] areas, and, in turn, from the [suburban] areas into the more rural counties.

Wolman also pointed out that, in the last 12 years, more septic tanks and cesspools were put in than were taken out in the previous 40, and that "careful distribution of sewage among the population in certain congested areas has been eminently successful." We cannot ignore the public health hazards inherent in inadequate water supplies and sewers or in public water supplies from grounds saturated with sewage. Some means should be found to render service with justice for all.

When we consider the great need and high cost of widening the distribution of adequate public water service, we must question whether the final answers in regard to the materials and methods to be employed have been found. Those we now use have stood the test of centuries of experience and

should not be too hurriedly put aside, but they, too, were new once and displaced something inferior. Modern inventions must not be ruled out.

There are economic studies which must be undertaken. No matter who owns the water works, they must face economic problems involving need versus cost, sources of capital funds, relative rights of classes of customers, and other questions that have to be answered.

Allocation of Costs

A generation ago one of the open questions in our field was the proper allocation of property and expense between general and fire service. Many studies were conducted, opinions given, and decisions made. Although there now appears to be rather widespread agreement on the proper methods of allocation for fire service, they are little used.

Much remains to be done in developing a consensus on the proper ways to spread the total cost of general service among the various classes of customers. How should rates be fixed for large users or for those buying for resale? Some representatives of such customers insist on rates yielding very slightly more than the incremental cost of the service. They feel that, if they pay the additional out-of-pocket expense of producing and pumping the water that they need, plus a token premium, they are carrying their share of the total load. Added output does reduce the unit cost and helps to pay carrying charges, but it uses up excess plant capacity and thus may add to carrying charges. Is a water works ever justified in offering incentive rates to bring an industry to a community? Should water ever be delivered at less than the total unit cost? How should the unit cost per 1,000 gal be determined for classes of customers and for individual large users? There should be consultation among us to find an acceptable formula for answering such questions.

Extension Policy

In establishing extension policy, it becomes necessary to estimate the proportion of new revenue that will be used up in paying the operating expenses. It is easy to calculate the cost of fuel, energy, and chemicals required to serve the extension. There will probably be no need for additional personnel at the pumping station, in the office, in the outside clerical force, or even in the distribution system maintenance force. Consequently, the added operating expense directly attributable to the extension will be very small. Yet the adding of customers year by year is not accompanied by a reduction in the ratio of operating expenses to operating revenues. In times of stable prices for materials and labor, the operating ratio will remain practically constant, while, in periods of rising prices, the operating ratio will go up; in neither instance is the ratio trend substantially affected by adding customers. An economic study should be made to find out why this is so. Meanwhile the fact should be kept in mind in considering service extensions.

Depreciation

Depreciation is another subject for economic study. For several years the accountants preempted the field, so far as regulated utilities were concerned, and before that the engineers held sway. Recently economists have been

doing some talking. There are matters of fact and of policy that will probably never be finally answered, but they need to be given thought by us now and in the future.

Several years ago the AWWA sponsored a study of the retirement experience of water works facilities (*2*). It was and still is the only intensive investigation of the great mass of data on the subject available from a large number of plants. That study is valuable, but it should now be carried forward. The retirement experience data and curves should be employed to develop life expectancy curves for the same properties and facilities. These new studies require the services of trained actuaries and statisticians. When that work is done, water works managers will have some basis for fixing rates for annual depreciation, subject always to adjustments dictated by changing conditions and advancing knowledge.

In the same general field, work needs to be done in clarifying current thinking on accrued depreciation. Is accrued depreciation, as of any moment in time, a fact established by engineering studies giving weight to all known factors that will lead to ultimate retirement? Or is it a stage in the development of reserves for the amortization of the original investment within the estimated service life? Should the annual rate for depreciation be such that the accumulated reserve over the years will tend to follow the life expectancy curves, or should the rate be calculated so that the reserve will be built up over a straight line from the beginning of service life to its assumed end? What are the relative economic effects of the two methods?

Economists are also interested in the fact that we create a depreciation reserve sufficient to cover the cost of an item of property retired, but we replace the item with a much more expensive one. To this extent, we add dollars to our plant and property without equivalent plant enlargement. Some are saying that we are, in a sense, depleting capital by understating depreciation expense and that we should be allowed to reserve at a rate high enough to replace the property, not merely the dollars of investment. We should be giving some thought to that problem.

Efficiency Yardstick

We have not yet considered the possibility of devising a yardstick by which the economic efficiency of an individual water works system can be measured. We are free of competition and so do not have that check on efficiency. Each system operates in a world of its own. The engineers can calculate the efficiency of the pumps, the coefficients of the mains can be determined, and the meters can be tested. Even on these matters, however, there is rarely any attempt to compare results from system to system. The methods of calculating unaccounted-for water not only vary from plant to plant but from year to year in the individual plant. Are we making efficient use of our resources or are we wasting manpower, money, and materials? As stewards of national resources, we have no moral right to be inefficient.

The extent to which a plant meets the service desires of its customers is never measured, nor, of course, are plants compared with each other in this regard. Are our plants making the best and most economical use of the

water resources available to them? Some way should be devised by which such facts could be determined, so that waste of manpower and of natural and economic resources would become evident and avoidable.

The means will never be found if the searchers fix their minds on the difficulties to be overcome and neglect simple fundamentals. Clear thinking, with a disregard of irrelevant details, but with a firm determination to reach a sound answer, will often bring success.

Conclusion

The people of this country are living in a challenging period. It is a great age in which to work. The older water works men among us are fortunate because they have done so much to make modern life possible and pleasant. They look back with satisfaction over lives devoted to the ideal of better urban living, wider distribution of urban comforts, and expanding industry. They know that they have contributed to an essential community effort, and, if they have been awake and advancing through the years, they are proud of their lifework.

Younger men are coming on, and still younger ones are choosing future careers. They must decide whether the water works field is one in which they want to spend their lives. Many of them could probably take up work that would offer more money, but our field presents a challenge to energetic men wishing to devote their talents to essential public service. There is much to be done by young men of talent, courage, and a sense of social responsibility.

NOTE: *In commending the author upon the challenge presented in his address,* Engineering News-Record *did not fail to point out the one fundamental problem that faces the water works field, as well as all other fields of public employment, in attracting personnel capable of doing "the work to be done." That, of course, is the problem of meeting competition for the available men—a problem that will be solved only by enabling water utilities to meet the current price for manpower.*—ED.

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EJC and the Engineering Profession

By Thomas A. Marshall Jr.

A portion of an address presented on Feb. 26, 1954, at the joint meeting of the Akron Section, American Society of Mechanical Engrs., and the Akron Dist. Society of Professional Engrs., Akron, Ohio, by Thomas A. Marshall, Secy., Engineers Joint Council, New York. (The AWWA accepted an invitation to become a member body of EJC as of Mar. 17, 1953.)

THE engineer has become a symbol for precise work and accuracy because of his objectivity and his search for facts upon which to base his contributions to research, development, design, production, and distribution in improving living standards.

In doing research for this paper, the author was amazed to discover the lack of accuracy or clarity in the delineation of the elements of a subject of extreme importance and interest to the entire engineering profession. It is a matter that is discussed frequently by engineers at meetings and in their day-to-day contacts—the subject of "unity of the engineering profession."

"Unity" has several meanings and is variously interpreted by different individuals. "Absence of diversity," "uniformity," "unity of sentiment," "unification," and "continuity without deviation or change" are some of the accepted definitions of unity.

In the author's opinion, there are two essential elements of engineering unity. First, the "unity" organization must be formed, not to achieve unity in the senses mentioned before, but to achieve unity in the sense of "solidarity," meaning a community of interests, objectives, standards, and responsibilities that will permit the profession, as a group, to express its opinions, manifest its strength, or exert its influence as a unit in specific areas. This does not require "uniformity," or "absence of diversity," or "unification," or "continuity without deviation or change."

An excellent example may be found in the American Medical Assn. This organization is frequently alluded to in discussions on engineering unity. Many doctors disagree with some of its policies and actions, and some doctors are not even members. It does, however, express the opinion of the medical profession as a group, without the unanimity implied in some definitions of unity.

Second, there must be—and this may be considered by some as heresy—a recognition, expressed in the purposes and actions of the "unity" or "solidarity" organization, of the value of self-interest, individual and organizational, as a motivating force for successful and continuing operation. It is impossible to maintain an engineering unity organization without the support of the engineers; it is impossible to get or count on their continued support unless the unity organization includes, among its primary aims, aiding the

engineer to improve himself and improving the professional climate for engineering.

Within the engineering profession, there are already a number and variety of organizations—unity organizations, at least in one sense. Engineers concerned with one broad area of engineering, such as civil, mechanical, electrical, and so on, have formed societies to work together in developing and promoting an interchange of ideas within that basic area. Such societies have for years served as a core for their members, within their areas of technical competence. They have developed standards and codes for operation and safety that have become recognized and used by many outside the profession. They have become national authorities and spokesmen in their field. But, it must be remembered that their primary reason for existence is to help their individual members to develop themselves. This is a prerequisite to all other activities. Similarly, there are local or regional societies or councils that serve the common interests of engineers residing in specific communities or sections.

Some effort must be focused on the self-development of engineers in order to create an organization that will enable engineers as a group to serve mankind without selfishness. When this is done, it will permit the individual members of the profession, and the profession as a whole, to make the greatest possible contribution to the national welfare. This will, in turn, create a climate in which the individual engineer can function more effectively as a recognized professional person.

The American Medical Assn. and the American Bar Assn. are virile unity organizations within their professions primarily because they aid doctors and lawyers to develop themselves professionally. True, their contributions to the national welfare are notable, but these organizations are supported because they aid doctors and lawyers to develop themselves.

Areas of Unity

Next to be considered are the areas in which an effective unity organization in the engineering profession might operate to achieve these goals. There are problems arising from time to time within the profession that are generally national in scope and in importance, that the existing societies individually are not in a position to handle. Many of these problems are nontechnical but require a degree of coordination of technical competence in several fields.

Such problems fall into two broad categories: First, those that affect the individual engineer only indirectly, in much the same manner as they affect any individual citizen. These might be called "national welfare" or "public service" problems. Second, those that affect the individual engineer much more directly. These might be called "professional" problems.

Public Service Activities

In the first category are problems in connection with which a small group of highly competent members of the engineering profession perform a much needed service to the nation on behalf of the profession. These problems and their solutions are most important. They are being handled now, and have been for many years. The history of accomplishments in this area is impressive. It can be found in the annals of the Engineering Council of the National Technical Societies of America, founded in 1917, and its successor, the American Engineering Council, formed in 1920. At present this is one of the

major areas of activity of the Engineers Joint Council (EJC).

The importance of such activities has long been recognized by many prominent engineers. Herbert Hoover (*1*), first president of the American Engineering Council of the Federated American Engineering Societies, commented succinctly on this matter in his address to the first meeting of the council in 1920: "The Federated American Engineering Societies stands somewhat apart among these great economic groups [employers, farmers, merchants, and labor] in that it has no special economic interest for its members. Its only interest in the creation of a great national association is public service, to give voice to the thought of engineers in these questions."

Some examples of these national welfare activities are the American Engineering Council's study on "Waste in Industry" and its survey of commercial aviation in 1925. The latter resulted in the establishment, in the US Dept. of Commerce, of the Bureau of Aviation, the forerunner of the present Civil Aeronautics Board and Civil Aeronautics Administration.

Current examples include: the EJC report on "Principles of a Sound National Water Policy"; the work of the EJC National Engineers Committee on the Industrial Disarmament of Japan; and the statement of the EJC Atomic Energy Panel to the Joint Congressional Committee on Atomic Energy, recommending changes in the Atomic Energy Act to permit the engineering profession to make its maximum contribution to the development of atomic energy for peaceful purposes.

Professional Activities

Most members of the engineering profession understand the necessity for these national welfare or public service activities. Many of them, however, find such work insufficiently stimulating to their own enthusiasm. They will not underwrite a unity organization devoted solely or primarily to such activities. Unless the organization pursues activities that will help individual engineers professionally, they, in turn, will not support it or provide the grass roots backing through the technical societies so necessary for the continuity of any successful unity organization to serve both engineers and the nation. For this reason, if for no other, the EJC must be concerned with problems in the professional area, the solutions to which can be of direct benefit to the individual engineer.

One such area of activity is the development of the engineer in his profession, through the accrediting of engineering curricula, the formulation of standards of ethics, the establishment of adequate minimum registration requirements, and the like.

Other activities concern the relations of the engineer with his employer—for example, studies on engineering income and personnel supply and demand. Also in this category are the problems of monitoring national or state legislation from the standpoint of improving or preventing damage to the climate in which the profession of engineering is practiced.

The Engineers' Council for Professional Development has done a noteworthy job in developing engineers from the time when, as high school students, they begin to think about engineering until 5 years after they have received their baccalaureate degree. The ECPD has become the recognized accrediting agency for engineering curricula in the colleges and universities. It has developed canons of ethics that have set the pattern for the entire profession.

The now classic EJC report, "The Engineering Profession in Transition," published in 1946, is another example of professional activities, as are the efforts of the EJC Engineering Manpower Commission and the National Society of Professional Engrs. to improve the utilization of engineers and to provide comprehensive and basic information of value to employers of engineers and to engineers themselves in the resolution of their mutual problems relating to working conditions. Another example can be found in the activities of the EJC Labor Legislation Panel. This panel was most successful in having provisions on professional personnel written into the federal Labor-Management Relations Act of 1947 (the "Taft-Hartley Act"). The panel is continuing its work to insure that these provisions are retained in any amended version of the act. Through the joint efforts of the EJC and the National Society of Professional Engrs., the engineer employee practicing his profession was exempted from the provisions of the Salary Stabilization Act.

Public Relations

Associated with these professional and national welfare activities is the necessity for an overall public relations program. A successful public relations program will be a partial solution, at least, of the problem of recognition of the engineer by those outside the profession. Although much remains to be done, progress is being made in this area, too. The EJC and its committees have stimulated a rapidly growing appreciation of the engineering profession in Congress. The participation of the EJC Engineering Manpower Commission in the planning for national mobilization has served to underscore the important contributions of engineers to the national economy and the necessity for forthright action in connection with the mobilization of specialized personnel. Not only Congress, but the Dept. of Defense and other executive branches of the federal government as well, have been made aware of this matter.

Organization of EJC

The EJC was organized in 1941 as the "Engineers Joint Conference." The conference grew out of the liaison that had existed for many years between the secretaries of the four founder societies—the American Society of Civil Engrs., the American Institute of Mining and Metallurgical Engrs., the American Society of Mechanical Engrs., and the American Institute of Electrical Engrs. Early in the mobilization immediately preceding the United States' entry into World War II, the founder societies had received a number of requests from various government agencies for information and aid in areas of interest to the profession. It was decided by the four societies that a formal organization could best meet these needs. At the outset, the Engineers Joint Conference was composed of the presidents and secretaries of the founder societies. The American Institute of Chemical Engrs. became the fifth participating member in 1942. As the scope of its activities expanded, the functions of this organization became of greater significance than that implied by the title of "conference." Accordingly, the name was changed to "Engineers Joint Council" in September 1945. Representation of the constituent societies on the council was increased and a formal constitution adopted.

In 1949 the EJC sponsored a meeting to discuss the development of increased unity within the engineering

profession. Out of this conference was formed an "Exploratory Group," with representatives from ten national societies in addition to the five EJC member bodies. During more than 2 years of study the Exploratory Group developed a program and plan acceptable to most of its members. This was submitted to the EJC in January 1952.

After some discussion the EJC constitution was modified so that the first step in developing the unity organization in accordance with the recommendations of the Exploratory Group could be taken. The first modification of the constitution changed the requirements for membership to permit the extension of invitations to other societies to join the EJC and, at the same time, provided for proportional representation from its members.

The change in constitution was ratified by the five constituent societies of the EJC on Dec. 7, 1952, and, on Dec. 31, 1952, invitations to join were extended to eight other societies. Acceptances were received from the American Water Works Assn., the Society of Naval Architects and Marine Engrs., and the American Society for Engineering Education. The eight constituent national societies have a total membership in excess of 170,000, not counting student members.

The American Assn. of Engrs., the American Society of Heating and Ventilating Engrs., and the Institute of Aeronautical Sciences took no action on the invitations, which expired Dec. 31, 1953. Two other societies rejected the invitation to join the EJC. In its letter of rejection, the Institute of Radio Engrs. (IRE) requested continued cooperative activity with EJC on specific problems of mutual interest. Its rejection was dictated by two basic policies of long standing: first, that the IRE shall not engage directly or indirectly in legislative activity; and second, that the IRE is not entitled to represent its members on social or general professional matters and shall not, as a society, take a stand even on technical matters.

After considerable study and a number of meetings of a special joint committee, consisting of three members of the EJC and three representatives of the National Society of Professional Engrs. (NSPE), the latter organization also declined to accept the invitation to joint the EJC. A resolution adopted by the NSPE board of directors on Nov. 7, 1953, rejected the invitation "at this time, in accordance with the firm conviction of this Board that no organization can adequately represent the engineers of this nation, unless that organization is based primarily on individual membership and constituted to assure prompt and effective means of communication between the individuals, their local or state units, and their national governing body." The resolution went on to express the firm desire of the NSPE to continue joint efforts toward the most effective action possible by both organizations.

Although the NSPE did not accept, the study made by the joint committee did much to further a mutual understanding between the two organizations. In addition, it has provided a very valuable document for the guidance of the EJC. The joint committee on EJC-NSPE relations is being continued to explore further areas of cooperation between the two societies.

At present the EJC is composed of nineteen representatives of the eight constituent societies, in proportion to their membership. Representatives and alternates on the council must be members of the governing boards of the societies they represent. The presi-

dents of the constituent societies are members ex officio of the council. The president and vice-president of the EJC and the members of the Executive Committee are elected for 1-year terms from the representatives at the annual organizational meeting. The EJC constitution provides that the president, the vice-president, and the other members of the Executive Committee must each be from a different society.

Objectives and Activities

The objectives of the EJC, as expressed in its constitution, are:

1. To advance the general welfare of mankind through the available resources and the creative ability of the engineering profession
2. To promote cooperation among the various branches of the engineering profession
3. To advance the science and the profession of engineering
4. To develop sound public policies respecting national and international affairs wherein the engineering profession can be helpful through the services of the members of the engineering profession.

There is ample recognition of the necessity for providing a balanced program. The EJC carries on activities both in the national welfare or public service area and in the professional area.

Public Service Activities

The EJC Committee on Engineering Sciences cooperates with the National Science Foundation in initiating and developing basic research in the engineering sciences. The committee also assists members representing the engineering profession on the National Science Foundation Board. It has a task committee working actively with the National Science Foundation on the development of the engineering section of the National Scientific Register.

The EJC Committee on International Relations acts as a coordinating agency between the profession in the United States and in foreign countries. The committee has been working actively with the Pan-American Federation of Engineering Societies, of which the EJC is the United States member. The committee was instrumental in helping to rebuild the engineering libraries of war-torn countries by acting as a clearinghouse for contributions of books that were delivered through the medium of the United States Book Exchange.

Some of the work of the EJC National Water Policy Panel and the EJC Atomic Energy Panel has already been mentioned. There is also an EJC Advisory Committee to the Lewis Historical Publications, the official publishers of *Who's Who in Engineering.*

The EJC National Engineers Committee, in addition to its work on the industrial disarmament of Japan, has continued to function in the capacity of adviser to such government agencies as the Federal Civil Defense Administration, and to the President in connection with the establishment of the St. Lawrence River Joint Board of Engrs.

Professional Activities

In the area of professional development, the EJC is continuing, through its Special Surveys Committee, its studies on personnel supply and demand and on professional income. The NSPE is also represented on that committee. A study, "Professional Income of Engineers, 1953," covering nearly 70,000 engineers employed in industry, education, and government, has just been released.

The activities of the EJC Engineering Manpower Commission are well known. The commission has been working for the past 3 years to secure more effective use of engineers by government and industry in furthering the national health, safety, and welfare. It has also done much to stimulate the interest of qualified high school graduates in careers in engineering. Thus, the activities of the commission actually lie in the areas of both professional and public service.

Of major significance in the professional area, however, is the work of two other EJC committees. One, the Committee on Employment Conditions, through the constituent societies, is hard at work studying the interest of engineers in collective bargaining, in professionalism, and in other matters that affect their conditions of employment.

The Committee on Recognition of Specialties in Engineering was formed as a result of a suggestion from the Joint Committee on the Advancement of Sanitary Eng. Difficulties have been encountered by sanitary engineers in being recognized as competent within their specialty, especially by those outside the engineering profession. The problem was discussed with the Joint Committee on the Advancement of Sanitary Eng., and the EJC committee is watching with a great deal of interest the work being done by the joint committee in developing plans and procedures for the recognition of sanitary engineering as a specialty. Current thinking is along the lines of specialty boards to examine candidates in a manner somewhat similar to that employed in the medical profession. When the procedures have been worked out in full detail and tested in the pilot study on sanitary engineering, they will unquestionably be extended to other fields, cutting across the interests of more than one of the EJC constituent societies. Hydraulics and nuclear engineering are two examples.

Other Activities

The EJC is in the process of change. It is entirely different now from what it was 2 years ago. As its activities progress, and as the council studies and implements the recommendations of the Exploratory Group, it will continue to change. It may well become the unity or solidarity organization for the profession.

One of the recommendations of the Exploratory Group had to do with the affiliation of state, regional, and local societies with the EJC. A special committee is now actively working on that problem and is studying the affiliation of national societies that meet all the requirements for EJC membership except size.

The matter of individual participation in the EJC is deemed to be of such importance that the Executive Committee itself is devoting additional time to the problem. Real progress can be expected. In order to develop a channel of communications between individual engineers and the EJC, a bimonthly bulletin is being planned for distribution to local, regional, and state engineering societies and councils. Through this medium, the EJC will be able to tell the individual members of the profession what it is doing and how it is developing. It is hoped that the individual members will follow this news and contribute suggestions for improvements, especially those that will help build the EJC into the organization engineers want and need.

Conclusion

If, in its activities, the EJC gains the support of the individual members

of the engineering profession, it can become the unity organization desired by all. It must be emphasized, however, that the EJC cannot and will not become a collective-bargaining agency, nor will the existing technological societies. To those who make reference to the strength of unity organizations in the medical and legal fields, it should be pointed out that the members of both of those professions are predominantly self-employed, so that there is no collective-bargaining problem. The author is firmly convinced that, to attain recognition and true professional status—especially in the eyes of the public—initiative, resourcefulness, creativity, and individual incentive need to be encouraged among the members of the engineering profession. These are the tools that will make it possible to develop engineers professionally, improve the practice of engineering, and provide effective service in the national welfare and the public interest. These factors are the direct opposite of collective bargaining.

Engineers, as professional men, have an obligation to devote a share of their time, efforts, and funds as a service to the nation in matters affecting the national welfare or in the public interest. If they do not carry on such activities, they will not maintain a professional status.

Activities of the type carried on by the EJC develop out of the need for them. It is of tremendous significance that, only a year after the American Engineering Council had ceased its operations, it became necessary to form another organization—the EJC—to fill this need, or concede that the engineering profession as a whole was voiceless in matters of national concern. Since 1917, except for 1 year, there has been an organization engaged in such operations.

A successful and continuing unity or solidarity organization to serve the engineering profession can be built upon the framework already established and being developed in the EJC, if it receives constructive support. Unless its members build the EJC into the spokesman for the engineering profession in the areas of public service and professional activity, engineers will find themselves represented by other, less qualified, organizations hardly distinguishable from labor unions. The benefits that engineers, as individuals, get from the EJC—or from any other organization, for that matter—will be in direct proportion to the interest and support they give to it.

Reference

1. Hoover, H. C. Some Phases of Relationship of Engineering Societies to Public Service. *Mech. Eng.*, **42**:722 (1920).

Editor's Note

AWWA representation on EJC committees is as follows: Committee on Engineering Sciences, Richard Hazen; Committee on International Relations, Thomas P. Browne; Committee on Constitution and By-Laws, Harry E. Jordan; National Water Policy Panel, Abel Wolman; Atomic Energy Panel, Harry E. Jordan; and Engineering Manpower Commission, Samuel B. Morris, Hubert F. O'Brien, and William J. Orchard.

Survey of Water Revenue Bond Financing

By D. L. Erickson

A paper scheduled for presentation on May 26, 1954, at the Annual Conference, Seattle, Wash., by D. L. Erickson, City Engr. & Director, Dept. of Parks, Public Property & Improvements, Lincoln, Neb.

WHEN Lincoln, Neb., was planning its current $8,500,000 water supply expansion program, one of the problems was whether to finance it by issuing government general-obligation or water revenue bonds. The home rule charter governing the city provided for the issuance of general-obligation bonds after approval by a majority of the electors, but the charter was silent on the issuance of revenue bonds. All other cities in the state, except for a few with home rule, had the right under state statutes to issue water revenue bonds without a vote of the electors.

Because, under the existing Lincoln charter, either type of bond required a vote of the electors—to approve a general-obligation issue or to amend the charter so as to authorize the city council to issue revenue bonds—it was decided to explore the latter method of financing. One reason for favoring revenue bonds was the fact that the city was considering the issuance, at a later date, of a substantial amount of general-obligation bonds for various other public improvements. The interest rates on these bonds might be adversely affected by the prior issuance of $8,500,000 worth of general-obligation bonds for the expansion of the water supply.

A review of available water works and financial literature disclosed many excellent articles on water revenue bonds, but no information was found on a number of questions. Because of widespread interest in the subject, the AWWA sent out a simplified, one-page questionnaire to members in 93 municipalities—one in Vermont and two in every other state except Nevada, where there are no AWWA members connected with publicly owned water plants. A total of 69 returns, or 74 per cent, was received, representing every state except Nevada. The results are summarized below.

Questionnaire Results

1. *Does your municipality have legal authority to issue water revenue bonds for the purpose of making capital additions to its water works system?*

Yes, 51 (38 states). In 9 states—Delaware, Indiana, Massachusetts, New Jersey, Oklahoma, Oregon, Rhode Island, Vermont, and Wyoming—the cities queried were not authorized to issue water revenue bonds.

2. *Is such authority derived from the constitution, statutes, or home rule charter?*

Of the 51 cities permitted to issue water revenue bonds, 40 received this authority from state statutes, 5 from home rule charters, and 6 from a combination of state statutes or constitutions and home rule charters.

3. *Does the governing body have authority to issue such water revenue bonds without the vote of the electors?*

Of the 51 cities authorized to issue this type of bond, 34 (25 states) were not required to submit the question to a vote of the electors.

4. *If a vote of the electors is legally required, what affirmative vote is necessary for passage?*

Of the 17 cities under this requirement, 10 needed a majority vote; 4, a two-thirds vote; 2, a three-fifths vote; and 1, a four-sevenths vote.

5. *Can revenue from existing water works also be used to service bonds issued for the purpose of making improvements to or extensions to the existing water works system?*

Yes, 49.

6. *What maximum term of years is legally permitted for the water revenue bonds?*

Max. Period yr	No. of Cities
10	1
15	1
20	7
25	1
30	8
34	1
40	13
50	2
no limit	13
	47
no answer	4
Total	51

7. *What limitations exist on the total amount of water revenue bonds that may be issued?*

Limit	No. of Cities
none	21
13% tax value	1
5% tax value	1
10% tax value	2
2.5 times 1 year's debt service	1
1.5 times 1 year's debt service	2
no answer	23
Total	51

8. *Does the municipality give a mortgage upon the physical property of the water works system as security for water revenue bonds?*

Yes, 10; no, 39; no answer, 2.

9. *May such water revenue bonds also be secured by city taxing power?*

Yes, 18; no, 32; no answer, 1.

10. *When did your municipality last issue water revenue bonds?*

Period	No. of Cities
1924–30	2
1931–40	7
1941–50	13
1951–53	16
never	12
no answer	1
Total	51

11. *What was the maximum term?*

Term yr	No. of Cities
10	2
15	2
17	1
19	1
20	14
23	1
24	1
25	2
30	6
34	1
35	1
40	2
	34
no answer	17
Total	51

12. *What was the average rate of interest paid?*

The following tabulation excludes all water revenue bonds issued prior to 1931 and considers only those bonds based on water revenue alone:

Year Issued	Term *yr*	Interest Rate *per cent*
1934	20	4.0
	20	5 yr, 4.0; 15 yr, 2.125
1938	?	2.75
	?	3.0
1939	24	3.75
1944	17	3.0
1947	15	2.047
1948	30	2.5–3.5
	20	2.125
1949	30	2.92
	20	1.75
	35	2.625
	20	2.555
	25	2.15
1950	19	2.0
	20	2.5
	34	2.75
1951	20	2.75
	20	2.5
	20	1.67
1952	30	2.92
	20	2.304
	30	2.846
	20	2.5–3.0
1953	?	2.625
	30	1.7
	15	3.5

13. *How did this rate compare with that of general-obligation bonds issued by the city for other purposes that same year?*

The replies to this question were not complete or very satisfactory. In 10 cities, no general-obligation bonds were issued in the same year; in 9 cities, the rate on general-obligation bonds was the same as on revenue bonds; in 13, the rate on revenue bonds was higher than on general-obligation bonds.

14. *What minimum debt service ratio [percentage of annual revenue to be allocated to debt service] was required?*

Ratio *per cent*	No. of Cities
none	13
1.5	5
1.3	1
1.33	1
no answer	31
Total	51

Observations and Conclusions

The replies to this brief questionnaire appear to warrant the following observations and conclusions:

1. The financing of water works improvements by water revenue bonds has become a widely accepted practice, as evidenced by the fact that cities in at least 38 states are now permitted to issue such bonds.

2. Approximately two-thirds of the states permitting the issuance of water revenue bonds do not require a vote of the electors.

3. More than half of the cities with authority to issue such bonds can do so for terms of 40 years or more.

4. More than two-fifths of the cities with authority reported no legal limitations on the total amount of such bonds.

5. More than three-fourths of the cities with authority do not give a mortgage upon the physical property of the water works system as security for water revenue bonds.

6. More than three-fifths of the cities with authority are not permitted to use the city taxing power as security.

7. The interest rate on water revenue bonds has varied from 1.67 per

cent on a 20-year bond issued in 1951 to 4.0 per cent on a bond with a similar term issued in 1934.

8. In the experience of the cities reporting, the interest rate on water revenue bonds is 0–1.5 per cent higher than on similar-term general-obligation bonds.

9. The highest debt service ratio requirement reported was 1.5 per cent.

Lincoln Program

To return to the Lincoln situation, the city officials decided to submit to the electors a charter amendment that would authorize the issuance of water revenue bonds for an unlimited amount and term. Opposition to the unlimited-amount provision arose at a public meeting prior to final city council action on the exact form of the amendment, and, as a result, it was decided to restrict the amount to $8,500,000, the estimated cost of the proposed improvement program. Consequently, any additional water revenue bonds for the financing of other water works improvements that may be needed in the future will again require a majority vote of the electors.

The charter amendment carried by a 6:1 majority in an election held in May 1953. It was intended to sell the bonds soon thereafter, but, on account of the rise in interest rates occasioned by the issuance in June of a large loan by the federal government at 3¼ per cent, the city deferred the sale until November. It then marketed a $6,000,000 issue of 30-year bonds with approximately uniform total annual principal and interest payments. The average interest rate slightly exceeded 2.29 per cent.

In the author's opinion, it is unfortunate that this charter amendment was so limited. There should not be any legal limitation—except, perhaps, the setting of a maximum interest rate—on the right of the governing body to issue water revenue bonds for water works improvements to an existing municipal system, because the bond market will furnish sufficient protection to the public. If management is to be charged with the responsibility of providing an adequate water supply, it should be able to rely on the necessary capital funds without the delay and uncertainty of an election.

Planning Distribution System Improvements at Newport News

By H. E. Beckwith

A paper presented on Nov. 6, 1953, at the Virginia Section Meeting, Roanoke, Va., by H. E. Beckwith, Dist. Mgr., The Pitometer Associates, Inc., Pittsburgh, Pa.

IN the summer of 1952 problems of low pressure and inadequate supply began to develop in the Phoebus-Hampton section of the water works system of the Newport News, Va., Water Works Commission. This system serves a population of 150,000, including not only the city of Newport News but the entire peninsula from above Lee Hall down to Phoebus (see Fig. 1). The 582 miles of main in the distribution system range in size from 2 to 34 in.

Raw water is secured from two storage reservoirs, one situated at Lee Hall and the other at Harwoods Mill. Auxiliary supply during periods of high consumption is obtained from the Chickahominy River and Skiffes Creek. Filter plants and pumping stations are located at Lee Hall and Harwoods Mill. Discharge from the Lee Hall station is through three mains, 27, 24, and 18 in. in diameter. The discharge from the Harwoods Mill plant is through one 30-in. main. Elevated storage in the system consists of 150,000 gal at Lee Hall, 1 mil gal at the Sixtieth Street station, 1 mil gal at Phoebus, 100,000 gal at Fox Hill, and 125,000 gal at Langley View. The average consumption in 1952 was 13.7 mgd, with a peak day of 19 mil gal.

The most dramatic evidence of trouble in 1952 was the daily emptying of the elevated tank in Phoebus during the peak of the hot-weather demand. Consequently, the preliminary investigations were centered in this area, to determine whether the difficulty was due to some easily remedied local condition, such as a closed or defective valve, a constriction in the transmission system, or a large leak.

The first step in the study consisted of the division of the Hampton-Phoebus area into four districts. Pitometers were used to measure the flow into each district for a 24-hr period, and this measured consumption was separated into industrial and domestic use. The amount of the former was determined by reading the industrial meters simultaneously with the district measurements. The population in each district was closely estimated by the use of census data, and a check was made to ascertain whether the resulting net daily per capita consumption was in excess of normal, a condition that would indicate the existence of a great deal of leakage. These measurements also gave information on variations in use and on peak demand periods. The results indicated the consumption pattern to be about as expected for the population and industry served.

Next, 24-hr pitometer measurements were made at the principal junction points on the mains from the

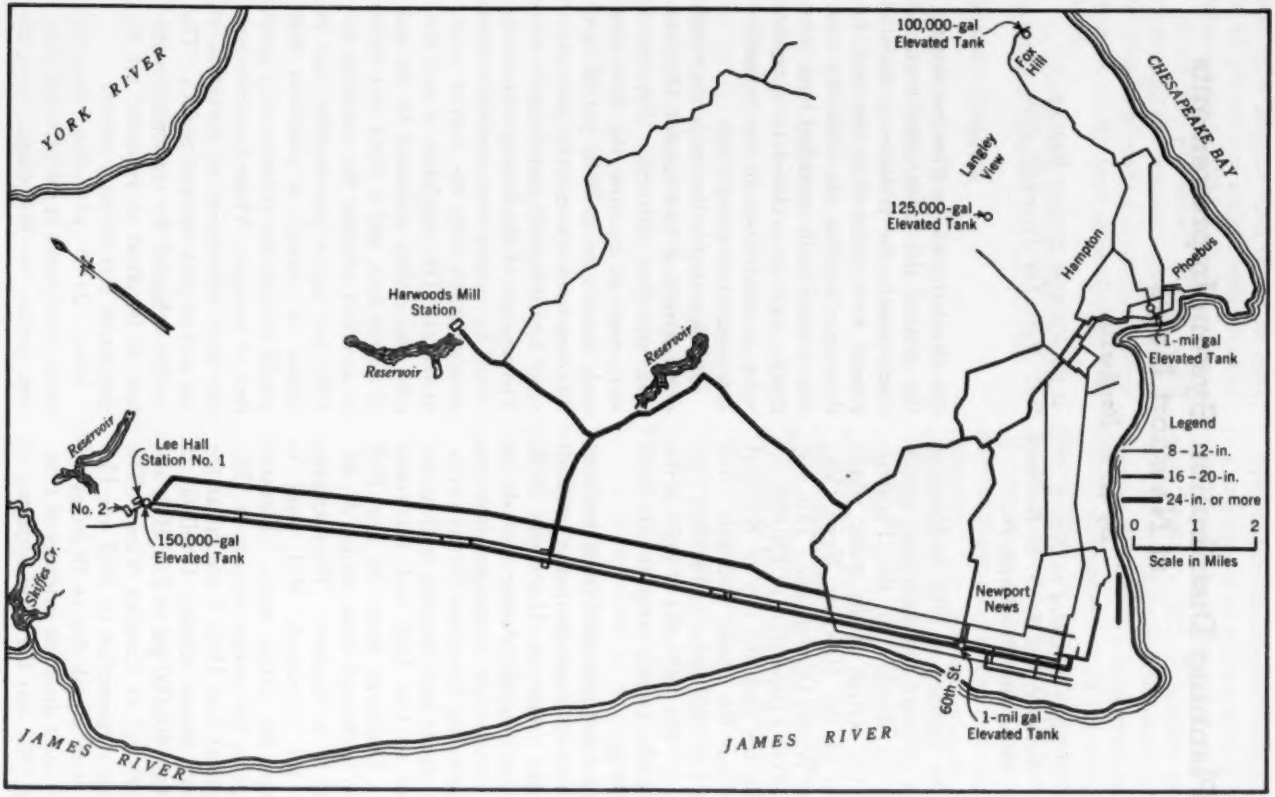

Fig. 1. Newport News Trunk Mains

The Newport News system serves a population of 150,000.

pumping stations to the trouble area, in order to determine whether there were any abnormal flow patterns, which might indicate an obstruction in the pipeline. The third step was the calculation of the Hazen-Williams coefficient of friction in the principal mains supplying the area, to find out whether any unusual conditions existed.

The final step was the determination of the hydraulic grade line between the pumping stations and the Phoebus tank at various hours of the day and night, using pitometer flow measurements. The measured hydraulic grade lines were compared with computed lines based on field data secured during the survey, in order to learn whether any radical difference existed. Any appreciable divergence between the theoretical and measured values would have indicated the presence of a constriction in the system.

These various studies and measurements, when taken together, proved that the present system was performing as well as could be expected. The only thing seriously wrong was that the demands being made upon it were beyond its capacity. Thus, the need for a new transmission line into the area was evident. Such a main, however, would cost nearly a million dollars and would affect the hydraulic conditions of the entire system—not only in the Hampton-Phoebus area, but in the Newport News area as well. Therefore, a complete engineering study of the whole system was undertaken.

System Survey

The purpose of the engineering study was threefold: [1] to determine the ability of present distribution facilities to meet existing demands; [2] to determine the probable amount and distribution of the water demand 15 years in the future; and [3] to design additional trunk mains to give adequate distribution, both for the present and for the future, including a 15-year schedule of construction timed to meet anticipated needs.

The probable future consumption of water for the period covered (through 1968) was based on a projection of population and per capita use trends. For neither of these factors has the normal growth pattern held true at Newport News in the past. Growth has been rapid whenever this country has been involved in armed conflict, but has been much slower during periods of peace. The population even decreased between the two world wars. In the expectation that the "cold war" will continue for years, it was felt that the prospect for this community lay between the extremes of war and peace, and the improvement program was designed accordingly. Should changes in the international situation occur, construction can be accelerated or slowed down as required. In any event, only the timing will differ, not the size and location of the designed mains.

It was found that the most probable population-served figure in 1968 will be 202,000 and that an average pumpage of 18.2 mgd will then be necessary. The peak daily demand was estimated at 25.5 mil gal. Provision also had to be made for the fact that this water is not to be taken at a constant rate and that additional capacity has to be provided for fire protection. These considerations determined the additional capacity requirements for mains leading from the pumping stations.

In order to find how this demand would be distributed, the system was divided into sixteen districts and the

flow into each was measured with the pitometer for a 24-hr period. The districts were studied individually, in a manner similar to the study of the entire system, in order to estimate the probable consumption, rates of use, and fire demand in each district in 1968. These investigations made it possible to design the size and location of transmission mains required to tie the system together into a well integrated unit.

The capacity of the present transmission system was found by means of a trunk main survey. As in the preliminary study of the Hampton-Phoebus area, measurements were made at the intersections of the principal transmission mains throughout the system in order to establish the flow pattern in relation to main capacity and to uncover any abnormal condition that might indicate an obstruction to the flow. By combining flow and pressure measurements, loss-of-head tests were made on the large transmission mains to determine the Hazen-Williams coefficient of friction and thereby find out how much of the original carrying capacity still remained. This study also indicated those mains whose capacity could be increased by rehabilitation, an improvement that can often be made at a fraction of the cost of new installations.

The next step was to make pressure measurements throughout the system to determine whether pressure losses were in accordance with the flow pattern and friction coefficients found. These measurements also revealed system bottlenecks, and studies of their cause and cure were made. Fire flow tests were also conducted throughout the system to determine the ability of the existing mains to meet the underwriters' requirements and to learn what additions would have to be provided to bring the system up to standard.

With all this information available, it was possible to decide on the improvements immediately needed and to distribute the balance of the program over the succeeding 15 years to meet the requirements anticipated for that period.

Proposed Program

The largest single item in the proposed construction program is a 20-in. main starting near the Harwoods Mill station, passing through a region not now served with water, and leading directly to the 1-mil gal tank in Phoebus. A number of 12-in. mains will be required to tie this proposed main to the existing system, and a considerable amount of 8-in. pipe will be needed to reinforce areas where distribution is weak. Also, some 16- and 12-in. lateral connections between existing mains in the high-value areas of Newport News will be required in order to increase fire streams. Although a total expenditure of more than $2,600,000 is proposed for main installations in the next 15 years, only a little more than 7 per cent of the money will be spent to improve conditions within the corporate limits of Newport News.

It is believed that the preparation of this 15-year program of construction will help the Newport News Water Works Commission to arrange the necessary financing. Moreover, the plan will prevent the haphazard construction of inadequate facilities and provide a soundly designed, properly integrated water distribution system which will operate economically and furnish adequate supplies throughout the area served.

Recent Developments in the Water Works Industry

By C. Kenyon Wells

A paper presented on Apr. 24, 1953, at the California Section Regional Meeting, Palm Springs, Calif., by C. Kenyon Wells, Asst. Gen. Mgr. & Asst. Chief Engr., Water Dept., Long Beach, Calif.

THE last few years have witnessed many improvements in water works practice, some far-reaching in their effect and others only of minor importance. Some have been scientific advancements in materials and equipment, while others have been practical improvements in methods and attitudes. This never ending progress presents a constant challenge to the water works operator to be ever on the alert for new and more efficient methods of operation.

Public Relations

In the field of management, special emphasis has recently been placed upon the improvement of public relations. This program, which has been stressed by the AWWA and been given wide publicity in the literature of the industry, has borne fruit. Proof of this statement lies in the willingness of the customer to accept justified rate increases and to vote bonds for additions to growing systems. The feeling has developed among managers that it is not enough simply to maintain service. Instead, a definite attempt has been made to give the customer the best service possible.

The increasing use of fast, emergency service vehicles—painted a distinctive color, bearing water department insignia, employing two-way radio, equipped with power-driven gate valve operating facilities and special tools, and manned by crews on an around-the-clock basis—has done much to improve service and make the customer feel that his water utility is on its toes. These crews handle all types of complaints and emergencies, large or small. Standby auxiliary power available at the main station transmitter during periods of power failure assures communication between headquarters and the radio-equipped service units under all emergency conditions.

In a further effort to promote good public relations, there has been a growing tendency to make it easier for the customer to carry on business with the utility. Conveniently located substations for the payment of utility bills, the use of the telephone to order service on or off, and the elimination of service deposits have done much to relieve the burden on the customer. The modernization and landscaping of utility offices and grounds have contributed in no small degree to better customer relations. If such a program is to be successful, however, every employee must exhibit sincere politeness and courtesy in dealing with the public.

In those utilities which have conscientiously adopted this new public relations program, managers and employees have found it tremendously

satisfying to work for the approbation and support of their customers.

Water Supply

In the field of water supply, recent developments have centered mainly around the perplexing problems resulting from a combination of phenomenal population growth and drought conditions. In Southern California, particularly, the overdraft on underground basins has reached alarming proportions. Supplemental water supplies appear to be the only solution. Whether they come from distant points, such as the Colorado or Feather River, or from the reclamation of sewage or sea water, they must be delivered to the areas affected and distributed either by direct pipeline or by spreading into underground basins from which the water can later be pumped.

Already, considerable amounts have been spread in an attempt to build up receding water levels. This has presented the problem of equitably distributing the costs involved. The alternatives include a straight ad valorem tax on property or a tax on each water producer in proportion to the amount of water he pumps. It is apparent that new legislation will be required to solve this problem.

Population growth in many areas has brought new subdivisions next door to pumping wells. To overcome complaints about noise made by conventional deep well turbine pumps in built-up areas, the water works operator has had to resort to sound insulation or to the use of a submersible pumping unit. The popularity of the latter has grown tremendously in recent years. Not only does it work noiselessly, but it can be installed without a pumphouse.

Centralized control of widely separated pumping wells has been finding favor with many utilities. Advances in electrical controls and instrumentation have made such arrangements possible. Use is made of a pair of wires to each well, which are either leased from the telephone company or installed by the utility. Occasionally radio control alone is used.

For several years considerable experimentation has been carried on in an attempt to increase the production of pumping wells. The gradually diminishing yield of a good well always has been disconcerting to an operator, and any method that will restore the original capacity is welcome. Some operators have tried surging the well with water under pressure or by dropping quantities of solid carbon dioxide into it. Others have circulated a solution of hexametaphosphate through the casing perforations and into the gravel formation, with good results reported. Another highly successful method is to lower a string of explosives into the well and detonate them at a location opposite the perforations. The accompanying shock wave and pressure surges appear to break up incrustations existing in the perforations and in the gravel formation, resulting immediately in a greater yield.

Tanks and Reservoirs

An innovation in the field of water storage is a more aesthetic approach to the construction of tanks and reservoirs. Underground reservoirs have been built with a reinforced concrete roof slab supported on concrete columns, over which a blanket of earth approximately 24 in. thick is placed.

The entire top can then be landscaped or laid out for recreational uses. Aboveground storage tanks have been constructed with a dome roof and center cupola and with a pilaster effect on the sides. These embellishments, although they have no real function, do break up the large, plain surfaces of the shell and make the structure look less like an oil storage tank. Obviously, the architectural elements are more important in a residential district than in an industrial area.

In the design of concrete reservoirs, a comparatively new rubber seal has been devised. This molded-rubber shape, placed between adjacent floor slabs when they are poured, is intended to provide a watertight seal.

Some of the new plastic coatings for the protection of steel water tank interiors against corrosion are beginning to gain in popularity, but the application of coal-tar enamels and the use of cathodic protection, either after the original coating has deteriorated or in the initial installation, remain common practices.

Distribution System

Perhaps the greatest strides in water works practice have been made in the distribution system. In many areas, particularly along the coast, where highly corrosive soils attack all unprotected iron and steel surfaces, water works operators have been forced to adopt protective measures that will safeguard their large distribution system investment.

Progressive operators in these regions now make soil corrosivity measurements in advance of water main construction, to determine the degree of corrosion protection needed. If the soil is found to be aggressive, nonmetallic pipe, such as asbestos-cement or steel cylinder with a dense inner and outer coating of Portland cement mortar is installed. If cast-iron pipe is laid in these areas, it is usually encased with a minimum thickness of 6 in. of neutral sand, which, it is generally believed, will protect the cast iron from destructive graphitization.

The corrosion of pipelines is also being controlled successfully by the use of coal-tar and plastic coatings and wrappings, and by cathodic protection. Ordinarily the latter is not applicable to a distribution grid system in a city, but it is used in protecting long pipelines.

The installation of water service laterals by boring instead of trenching is now common practice and saves considerable time and torn up street surfacing. Although most operators now employ copper tubing instead of galvanized steel for service laterals, serious consideration is being given to the use of plastic tubing, in the hope that it will give equally long life at a much lower cost.

It should be mentioned, also, that many operators are turning to the use of gate valves with all-bronze internal working parts, including discs. These are somewhat more expensive than the bronze-trimmed gate valves with cast-iron discs, but it is thought that their use will prevent the building up of corrosion products on the inside of the valve, making possible a tighter shutdown and decreasing maintenance costs. Square-bottom gate valves in the larger sizes are now meeting the approval of many operators. It is also becoming more common to use inserting valves, which permit control valves to be placed in a line without interrupting service.

The last few years have shown a definite trend toward complete metering of the water system. With supplies becoming increasingly critical, it is essential that all water be accounted for. If there is accurate metering at the point of intake and the point of use, the water works operator will know at all times the condition of his system.

Fluoridation

Mounting interest is being shown in the fluoridation of public water supplies to minimize dental caries. It is doubtful if there has ever been a development that has focused as much attention on the community water supply as the introduction of fluoridation has. The number of artificially fluoridated supplies in this country has increased amazingly, until, by Feb. 1, 1954, it was estimated to exceed 850, serving more than 16,000,000 people. As would be expected, new precision feeders for adding fluorides to water both volumetrically and gravimetrically are on the market.

Looking back over the last few years, there can be little doubt that important progress has been made. The water works industry is large and vigorous. There is every assurance that this progress will continue to go forward at a high rate of speed.

Correction

A modification is required in the Tentative Standard Specifications for Gate Valves for Ordinary Water Works Service—AWWA C500–52T in order to bring up to date and correct an internal reference to another AWWA standard. Section 6.1 (Ends for Bell-and-Spigot Pipe) of C500 should be revised to refer to "Class D * pressure fittings" rather than "Class C * special castings," as required by AWWA C100. In addition, the supplementary footnote at the bottom of the page should be revised to read as follows:

*AWWA C100 Class D Bell Diameter:

Size of Pipe *in.*	ID of Bell *in.*
4	5.70
6	7.80
8	10.00
10	12.10
12	14.20

* * *

The rest of the table, giving bell diameters for larger pipe, remains unchanged.

Protecting Water Quality in Distribution Systems

By E. A. Reinke

A paper presented on Oct. 28, 1953, at the California Section Meeting, San Francisco, Calif., by E. A. Reinke, Chief, Bureau of San. Eng., State Dept. of Public Health, Berkeley, Calif.

SINCE 1950 engineers from the Bureau of Sanitary Engineering of the California Dept. of Public Health have made sanitary surveys of many public water supplies as part of a 10-year census. This paper is intended to summarize the defects found in water distribution systems brought to light by the surveys, and to indicate what may be done to correct them and prevent similar defects in the future.

The defects fall into three general groups: [1] those due to conditions around tanks, reservoirs, and wells feeding directly into water systems; [2] those due to physical, chemical, or biological changes within the pipe system; and [3] those due to illicit or accidental entry of foreign material into the system. The very few quality complaints now being received usually relate to taste, odor, color, and hardness. The term "defects," as used in this paper, includes any conditions that may result in impairment of water quality.

Reservoirs and Tanks

The most hazardous defects found were at underground reservoirs with sewers close by. Sewage overflow during storms might run directly to the reservoirs, or contamination from leaky sewers might seep through the ground and the reservoir lining, thus reaching the water out of sight of the casual observer. In one instance, a dye was added to hillside drainage to see whether seepage into a reservoir would occur. The reservoir was supposedly protected by a drainage ditch to divert surface water, but the ditch lining was not tight and dyed water readily seeped through. It is interesting to note that the AWWA Committee on Potable-Water Storage Reservoirs, in its 1953 report (*1*) recommended "automatic disinfection of all water drawn from any open reservoir, unless an ample residual of a disinfecting agent is at all times carried through the reservoir to the distribution system." * Observations in California clearly show that this recommendation is justified, and, in special circumstances, it may also apply to covered reservoirs.

Other contamination hazards generally reported at open reservoirs are bathing, fishing, and drowning. Fencing and patrols minimize but do not entirely prevent them. Moreover, they have also occurred in covered reservoirs.

The greatest objection to open reservoirs is the fact that they collect wind-

* The committee added the qualification that, "In certain installations where flow changes are never rapid, manually controlled chlorination, with continuous attendance and recording chlorine residual devices, may be considered the equivalent of automatic disinfection."

blown debris and are subject to pollution by seagulls, ducks, mud hens, rodents, and other animals. In addition, plankton growths sometimes cause tastes and odors. It is suspected that seagulls may transport contaminated material on their legs and feathers from sewage-polluted sea water to open reservoirs. The thought is repugnant to consumers, and most of the larger systems in California have effectively controlled seagulls by stringing wires across the reservoir to prevent the birds from landing on the water surface.

Covering reservoirs is becoming a more common practice on new construction. The bureau's surveys showed many defects in covers. A simple board cover, the type most often employed, keeps light from the water and prevents algal growths, but cracks between the boards allow dust and bird droppings to be washed into the water by rainstorms. Although many articles have been published on proper manhole construction for reservoir roofs, a wide variety of openings is found. Not infrequently, the cover is left off to relieve the operator of the chore of removing and replacing it every time he finds it necessary to enter or inspect the reservoir.

In one instance, a few years ago, repeated high bacterial counts were traced to an elevated steel tank. On inspection, it was found that the roof manhole was open and several pigeons had entered and drowned in the water. At another installation woodpeckers reportedly entered through the walls of a wooden tank, could not get out, and eventually drowned.

Dead Ends

Dead ends are a continuing problem in many public water systems. Although good water works practice calls for the elimination of all dead ends, surveys have shown that, in numerous cities, the water works authority has not had the time, the money, or the interest to make needed system changes. Relief is sometimes afforded by a regular, well planned flushing program, but it should be emphasized that the results are only temporary.

Consumer complaints about rust, dirt, black water, gas, bugs, worms, and a wide variety of real or imaginary materials indicate that the water in the system is changed physically, chemically, or biologically in dead ends. Their complete elimination is the only satisfactory solution to this problem. Such a program will relieve the water works operator of many headaches.

Nuisance Organisms

Nuisance organisms entering the distribution system from the sources or from inadequately covered reservoirs are another major cause of trouble. *Crenothrix* and similar "iron bacteria," as well as bloodworms or chironomid larvae, have been reported from both large and small systems in the state. As a result of the growth and subsequent decay of *Crenothrix* within the water system, taste, odor, and color may become so bad that the water is unusable for domestic purposes. Cleaning such a system calls for heroic measures and causes a severe strain on relations between water works operators and consumers. The best solution to the problem is to control the organisms at the source and keep them out of the distribution system. In extreme instances, it has been necessary to abandon such sources in favor of other available supplies.

Chironomids are gnats about the size of mosquitoes and are sometimes mis-

taken for them. These insects lay their eggs on water surfaces. The jellylike sacs which develop attach themselves to the banks or walls of the reservoirs. The larvae, called bloodworms, become scattered throughout the system and appear in consumer taps. Complete fine-mesh screening of all openings is the only practical remedy thus far proposed to combat these offensive organisms.

Turbidity, Color, and Taste

Turbidity due to surface runoff to streams and reservoirs is a source of intermittent complaint in systems using unfiltered surface supplies. Sedimentation reservoirs, with or without preliminary coagulation basins and chemical treatment, have been valuable in reducing turbidity. The only permanently satisfactory solution, however, is the filtration of all water from surface sources.

Color may be due to iron or manganese, to certain mining wastes, to algae, or to organic compounds such as humic acid. Careful studies are usually necessary to determine the actual cause. Chemical treatment and filtration are generally required.

Chemical treatment may itself result in tastes and odors. Improper chlorination practices may produce chlorinous or chlorophenol tastes or odors in the water. Similarly, excessive doses of alum may cause an astringent taste and lead to secondary floc formation and turbidity in the distribution system. Such possibilities accentuate the need for competent, well qualified water system personnel. Adequate methods are available for the effective solution of most water works problems, but good design and construction will be of little value unless complemented by proper maintenance and operation.

Cross Connections

Recent investigations of outbreaks of waterborne disease have shown that the greatest health hazards in public water systems are those resulting from cross connections. The bureau's surveys have disclosed unprotected cross connections between public water systems and other pipelines on consumers' premises. Such lines may contain sewage, storm water, process water with a wide variety of chemicals, and secondary water supplies from private wells, streams, bays, and other salt water sources.

The California Dept. of Public Health has recently adopted revised regulations for the protection of public water supplies from backflow through cross connections. Valuable assistance was furnished the department by a committee of the California Section, AWWA, under the chairmanship of Ray L. Derby, Los Angeles Dept. of Water and Power. The regulations are published as an appendix to this paper.

To show that backflow through cross connections is not merely a matter of historical interest, a recent experience of the bureau engineers may be cited. In one of the state's larger cities, a survey showed inadequate protection of the water system at a new sewage treatment plant. After conferences with the staff of the city water, health, and sewer departments, the bureau advised, and the local health officer ordered, complete air gap separation of the sewage treatment plant system, with the water pipe from the property line to the air gap installation to be aboveground and fully exposed, in order to facilitate inspection. This arrange-

ment protected the city system but not the lines within the plant, although the bureau was assured by the sewer department that, with well trained and competent operators, no backflow could occur there. A few months after the air gap installation had been completed, one of the bureau's engineers visiting the plant observed bottled water in use for drinking purposes. On inquiry, he learned that sewage had appeared at all the drinking-water fountains one day. No one could explain the occurrence, but it was undoubtedly the result of a cross connection between a sewer and water line.

An unusual hazard from connections to a water system was noted a few years ago. A piped high-pressure gas system was being tested monthly for leakage by using water pressure from one of the Los Angeles County water districts. One day a consumer taking a bath lighted a cigarette just as gas, instead of water, came through the tap. The bathroom caught fire and the fire department was called. When the firemen hooked their hoses to the hydrant and turned it on, they also got gas instead of water, and the hoses became flame throwers. Obviously, someone had failed to provide proper protection against backflow to the water system. The incident was unusual only in that the private pipe system carried an inflammable gas instead of a liquid.

Recent occurrences of sewage backflow indicate that the danger of cross connections is not much different from what it was in the past. The surveys have demonstrated the need for continued watchfulness by both water works operators and public health officials.

One question raised by privately owned water companies is whether they can refuse service to consumers who will not provide backflow protection when they have an unapproved secondary water supply. The California Public Utilities Commission has a regulation which provides that:

> Whenever [1] there exists on any consumer's premises another source of water supply which has not been approved by the Department of Public Health of the State of California as safe and potable for human use, or [2] the consumer's premises are engaged in industrial processes using or producing process waters or liquid industrial wastes, or in handling sewage or any other dangerous substances, the utility may refuse or discontinue service until there has been installed on the consumer's service pipeline a suitable, approved double check valve installation or other dependable device to protect against backflow of water from the consumer's premises into the utility's system.
>
> The protective device or devices shall be of a design approved by the California State Board of Public Health and shall be installed at the expense of the consumer in a manner approved by the utility and in a location which is readily available to the utility for periodic inspection.

From the standpoint of the public health agencies, the provision of backflow preventive devices is not, in itself, a guarantee of satisfactory results. Regardless of the devices installed, a regular program of periodic inspections must also be carried on.

Reference

1. COMMITTEE REPORT. Potable-Water Storage Reservoirs. *Jour. AWWA*, **45**: 1079 (Oct. 1953).

APPENDIX

Regulations Relating to Cross Connections

Excerpts from the California Administrative Code, Title 17 (Public Health), Chapter 5 (1953).

Article 1—Purpose

7583. The purpose of these regulations is: [1] to protect the public water supply against actual or potential cross connections by isolating within the premise contamination or pollution that may occur because of some undiscovered or unauthorized cross connection on the premise; [2] to eliminate existing connections between drinking-water systems and other sources of water that are not approved as safe and potable for human consumption; [3] to eliminate cross connections between drinking-water systems and other sources of water or process water used for any purpose whatsoever which jeopardize the safety of the drinking-water supply; [4] to prevent the making of cross connections in the future; [5] to encourage the exclusive use of public sources of water supply; [6] to protect the drinking-water supply within the premise where plumbing defects or cross connections may endanger the drinking-water supply available on the premise.

The regulations are to be reasonably interpreted. It is the intent of these regulations to recognize that there are varying degrees of hazard and to apply the principle that the degree of protection should be commensurate with the degree of hazard.

These regulations are not to be construed as prohibiting local governmental authorities or water purveyors from establishing requirements regarding protection of water supply more rigid than herein indicated, where local circumstances warrant.

It is recognized that the control of cross connections requires cooperation between water purveyors and health agencies. The water purveyor has primary responsibility to prevent water from unapproved sources, or any other substance, entering the public water supply system. The health agency has the overall responsibility for preventing water from unapproved sources from entering either the potable-water systems within water consumers' premises or the public water supply directly.

Article 2—Definitions

7588. *Cross connections.* The term "cross connection" as used in these regulations means any unprotected connection between any part of a water system used or intended to supply water for drinking purposes and any source or system containing water or substance that is not or cannot be approved as safe, wholesome, and potable for human consumption.

7589. *Approved water supply.* The term "approved water supply" means any water supply approved by, or under the public health supervision of, a public health agency of the State of California, or its political subdivisions. In determining what constitutes an approved water supply, the State Department of Public Health reserves final judgment as to its safety and potability.

7590. *Auxiliary supply.* The term "auxiliary supply" means any water supply on or available to the premises other than the public water supply.

7591. *Approved check valve.* The term "approved check valve" means a check valve that seats readily and completely. It must be carefully machined to have free moving parts and assured watertightness. The face of the closure element and valve seat must be bronze,

composition, or other noncorrodible material which will seat tightly under all prevailing conditions of field use. Pins and bushings shall be of bronze or other noncorrodible, nonsticking material, machined for easy, dependable operation. The closure element (e.g., clapper) shall be internally weighted or otherwise internally equipped to promote rapid and positive closure in all sizes where this feature is obtainable.

7592. *Approved double check valve assembly.* The term "approved double check valve assembly" means an assembly of at least two independently acting approved check valves, including tightly closing shutoff valves on each side of the check valve assembly, and suitable leak-detector drains plus connections available for testing the watertightness of each check valve.

7593. *Air gap separation.* The term "air gap separation" means a physical break between a supply pipe and a receiving vessel. The air gap shall be at least double the diameter of the supply pipe, measured vertically above the top rim of the vessel, in no case less than 1 in.

7594. *Approved reduced-pressure-principle backflow prevention device.* The term "approved reduced-pressure-principle backflow prevention device" means a device incorporating two or more check valves and an automatically operating differential relief valve located between the two checks, two shutoff valves, and equipped with necessary appurtenances for testing. The device shall operate to maintain the pressure in the zone between the two check valves less than the pressure on the public water supply side of the device.

At cessation of normal flow, the pressure between check valves shall be less than the supply pressure. In case of leakage of either check valve the differential relief valve shall operate to maintain this reduced pressure by discharging to the atmosphere. When the inlet pressure is 2 psi or less the relief valve shall open to the atmosphere, thereby providing an air gap in the device. To be approved these devices must be readily accessible for maintenance and testing and installed in a location where no part of the valve will be submerged.

Article 3—Protection of Public Water System at Service Connection

7603. *Where protection is required:*

1. Each service connection from a public water system for supplying water to premises having an auxiliary water supply shall be protected against backflow of water from the premises into the public water system, unless the auxiliary water supply is accepted as an additional source by the water purveyor, and is approved by the public health agency having jurisdiction.

2. Each service connection from a public water system for supplying water to premises on which any substance is handled under pressure in such fashion as to permit entry into the water system shall be protected against backflow of the water from the premises into the public system. This shall include the handling of process waters and waters originating from the public water supply system which have been subject to deterioration in sanitary quality.

3. Backflow prevention devices shall be installed on the service connection to any premises that have internal cross connections unless such cross connections are abated to the satisfaction of the water purveyor and approved by the state or local health department.

It shall be the responsibility of the water user to provide protective devices as required under Section 7604.

7604. *Type of protection.* The protective device required shall depend on the degree of hazard as tabulated below:

1. At the service connection to any premises where there is an auxiliary water supply handled in a separate piping system with no known cross connection, the public water supply shall be protected

by an approved double check valve assembly.

2. At the service connection to any premise on which a substance that would be objectionable (but not necessarily hazardous to health) if introduced into the public water supply is handled so as to constitute a cross connection, the public water supply shall be protected by an approved double check valve assembly.

3. At the service connection on any premise on which there is an auxiliary water supply where cross connections are known to exist which cannot be presently eliminated, the public water supply system shall be protected by an approved reduced-pressure-principle backflow prevention device. A double check valve assembly may be used in lieu of such device if local experience indicates that double check valves are reliably operated and if approved by the water purveyor and local health agency.

4. At the service connection to any premise on which any material dangerous to health or toxic substance in toxic concentration is or may be handled under pressure, the public water supply shall be protected by an air gap separation. The air gap shall be located as close as practicable to the service cock and all piping between the service cock and receiving tank shall be entirely visible. If these conditions cannot reasonably be met, the public water supply shall be protected with either an approved reduced-pressure-principle backflow prevention device, or an approved double check valve assembly, providing the alternative is acceptable to both the water purveyor and the local health department.

5. At the service connection to any sewage treatment plant or sewage pumping station the public water supply shall be protected by an air gap separation. The air gap shall be located as close as practicable to the service cock and all piping between the service cock and receiving tank shall be entirely visible. If these conditions cannot be reasonably met, the public water supply shall be protected with an approved reduced-pressure-principle backflow prevention device, providing this alternative is acceptable to both the water purveyor and local health department. Final decision in this matter shall rest with the State Department of Public Health.

7605. *Frequency of inspection of protective devices.* It shall be the duty of the water user on any premise on account of which backflow protective devices are installed to have competent inspections made at least once a year, or more often in those instances where successive inspections indicate repeated failure. These devices shall be repaired, overhauled, or replaced at the expense of the water user whenever they are found to be defective. It shall be the duty of the water purveyor and the health department to see that these tests are made in accordance with the responsibility designated in Section 7583. Records of such tests, repairs, and overhaul shall be kept and made available to the water purveyor and the local health department.

Article 4—Protection of Potable-Water System Within Premises

7615. *Separate drinking-water systems.* Whenever the health agency determines that it is not practical to protect drinking-water systems on premises against entry of water from a source or piping system or equipment that cannot be approved as safe or potable for human use, an entirely separate drinking-water system shall be installed to supply water at points convenient for consumers.

7616. *Fire systems.* Water systems for fighting fire, derived from a supply that cannot be approved as safe or potable for human use, shall, wherever practicable, be kept wholly separate from drinking-water pipelines and equipment. In cases where the domestic water system is used for both drinking and fire-fighting purposes, approved backflow prevention devices shall be installed to protect such

individual drinking-water lines as are not used for fire-fighting purposes. It is hereby declared that it is the responsibility of the person or persons causing the introduction of said unapproved or unsafe water into the pipelines to see: [1] that a procedure be developed and carried out to notify and protect users of this piping system during the emergency; [2] that special precautions be taken to disinfect thoroughly and flush out all pipelines which may have become contaminated before they are again used to furnish drinking water. In the event the means of protection of water consumers is by disinfection of the auxiliary fire-fighting supply, the installation and its use shall be thoroughly reliable.

When disinfection of the auxiliary supply itself is depended upon to render the water safe, the means of applying the disinfectant under this regulation shall be automatic with operation of the pump or pumps employed with the dangerous water in question. Adequate supplies of chlorine or its compounds must be kept on hand at all times. Chlorine dosing equipment shall be tested daily and kept in good operating condition.

The public water supply must be protected against backflow from such dual domestic fire systems as detailed in Section 7604.

7617. *Process waters.* Potable-water pipelines connected to equipment for industrial processes or operations shall be disconnected therefrom if practicable. Where disconnection is not practicable, a suitable backflow prevention device located beyond the last point from which drinking water may be taken shall be provided on the feed line to process piping or equipment. In the event the particular process liquid is especially corrosive or apt to prevent reliable action of the backflow prevention device, air gap separation shall be provided. These devices shall be tested by the water user at least once a year, or more often in those instances where successive inspections indicate repeated failure. The devices shall be repaired, overhauled, or replaced whenever they are found to be defective. Records of tests, repairs, and replacement shall be kept and made available to the local health department.

7618. *Sewage treatment plants and pumping stations.* Sewage pumps shall not have priming connections directly off any drinking-water systems. No connections shall exist between the drinking-water system and any other piping, equipment, or tank in any sewage treatment plant or sewage pumping station.

7619. *Plumbing connections.* Where the circumstances are such that there is special danger to health by the backflow of sewage, as from sewers, toilets, hospital bedpans, and the like, into a drinking-water system, a dependable device or devices shall be installed to prevent such backflow.

The purpose of these regulations is not to transcend local plumbing regulations, but only to deal with those extraordinary situations where sewage may be forced or drawn into the drinking-water piping. These regulations do not attempt to eliminate at this time the hazards of back-siphonage through flushometer valves on all toilets but deal with those situations where the likelihood of vacuum conditions in the drinking-water system is definite and there is special danger to health. Devices suited to the purpose of avoiding back-siphonage from plumbing fixtures are roof tanks or separate pressure systems separately piped to supply such fixtures, recognized approved vacuum or siphon breakers, and other backflow protective devices which have been proved by appropriate tests to be dependable for destroying the vacuum.

Inasmuch as many of the serious hazards of this kind are due to water supply piping which is too small, thereby causing vacuum conditions when fixtures are flushed or water is drawn from the system in other ways, it is recommended that

water supply piping that is too small be enlarged whenever possible.

7620. *Pier and dock hydrants.* Backflow protection by a suitable backflow prevention device shall be provided on each drinking-water pier head outlet used for supplying vessels at piers or waterfronts. These assemblies must be located where they will prevent the return of any water from the vessel into the drinking-water pipeline or into another adjacent vessel. This will prevent such practices as connecting the ship fire pumping or sanitary pumping system with a dock hydrant and thereby pumping contaminated water into the drinking-water system and thence to adjacent vessels or back into the public mains.

7621. *Marking safe and unsafe water lines.* Where the premises contain dual or multiple water systems and piping, the exposed portions of pipelines shall be painted, banded, or marked at sufficient intervals to distinguish clearly which water is safe and which is not safe. All outlets from secondary or other potentially contaminated systems shall be posted as being contaminated and unsafe for drinking purposes. All outlets intended for drinking purposes shall be plainly marked to indicate that fact.

7622. *Water supervisor.* The health department and the water purveyor shall be kept informed of the identity of the person responsible for the water piping on all premises concerned with these regulations. At each premise where it is necessary in the opinion of the health department, a water supervisor shall be designated. This water supervisor shall be responsible for the installation and use of pipelines and equipment and for the avoidance of cross connections.

In the event of contamination or pollution of the drinking-water system due to a cross connection on the premises, the local health officer and water purveyor shall be promptly advised by the person responsible for the water system so that appropriate measures may be taken to overcome the contamination.

Experience With Hydraulic Remote Control

By Walter Jacobsohn

A contribution to the Journal by Walter Jacobsohn, Asst. Water Engr., Munic. Water Works, Haifa, Israel.

REMOTE control of centrifugal pumps with hydraulic transmission of signals from reservoir to pumping station is particularly useful in a country like Israel, where all accessories have to be imported and paid for in foreign currency. Only a bare minimum of such apparatus is being installed. The equipment is of simple design and does not require expert maintenance, which is often not available.

At the beginning of 1952 a hydraulic remote-control system was installed at the Wadi Risha pumping station of the Haifa Municipal Water Works. It has worked satisfactorily and given considerably less trouble than a much more expensive electrically controlled system at another pumping station nearby.

The centrifugal pumps at the Wadi Risha pumping station, el 150 (mean sea level datum), are fed by gravity from a reservoir adjacent to the station. The bottom level of this reservoir is at el 185 and its top level at el 205. The pumps discharge directly into the reticulation system through an 18-in. main and into a balancing reservoir of 570,000-gal (US) capacity 5.5 miles from the pumping station. The bottom level of the balancing reservoir is at el 230 and its top level at el 245. In 1952 the quantity of water varied from 2.0 mgd in summer to 1.3 mgd in winter.

At the pumping station, a pressure switch connected to the discharge pipe operates the automatic two-point starter of the electric motor driving the first pump. At standstill, the head in the discharge pipe varies between 80 and 95 ft, in accordance with the water level in the balancing reservoir, if no water is being supplied from it. In practice, this does not occur, and, owing to friction losses, the water level at the reservoir is always higher than the manometer at the pumping station indicates, the difference being greater in the daytime than at night.

As it is not desirable that the balancing reservoir be empty at any time during the day, the starting head of the first pump has been fixed at 85 ft, thus insuring a certain reserve of water in the event of failure of the power supply or other contingencies. While the pump is running, the manometer reading at the pumping station is between 170 and 180 ft, the sum of static lift and friction losses.

At the balancing reservoir, a self-closing valve is installed in the delivery pipe. It closes through the action of a float when the reservoir is full. If, at that time, the consumption of water is small, the manometric reading at the pumping station rises to nearly 210 ft, the peak of the performance curve of the centrifugal pump. The off position of the pressure switch is fixed at 190 ft, however, in order not to let the pump run against unnecessarily high pressure with low efficiency. If, at closing, the head does not rise to 190 ft owing

to sufficiently high consumption of water, the pump simply continues to discharge into the reticulation system, bypassing the reservoir until the consumption drops.

One 2,200-gpm pump has been capable of handling peak loads. If, in the future, the consumption grows, a second pump can be added.

Pressure Switch

The pressure switch is very sensitive to fluctuations. Surge at start and stop

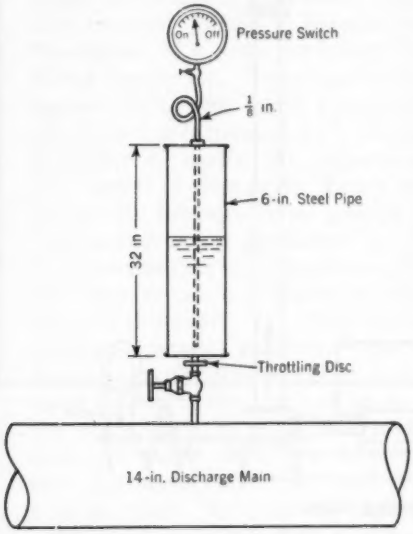

Fig. 1. Air Vessel and Throttling Disk

This device was installed to insure that the pressure switch is free from surge.

is not great enough to require dampers or pressure-regulating devices in the discharge main, but the pressure switch must, under all circumstances, be free from surge. Because the built-in dampers of the pressure switches proved to be insufficient, an air vessel made from a 6-in. steel pipe has been installed between the discharge main and the switch. A throttling disc with a hole 1 mm in diameter is inserted at the entrance of the air vessel (Fig. 1).

It has been observed that the surge dies down after 1.5 min, whereas it takes 5.5 min for the pressure to reach its final value if transmitted through the throttling disk and the air vessel. Thus, the pressure switch is safely protected from surge.

This delayed action of the pressure switch serves, at the same time, as a safeguard against too frequent starting of the electric motor if the automatic valve at the reservoir should fail to open. The entire cycle of rising and falling pressure takes 11 min; consequently, the motor will not start more often than once every 11 min, which does not do any harm to it or to the starter.

Self-closing Valve

The self-closing valve is an essential part of the scheme. At the time of installation, a float valve of suitable size was not available. Instead, a standard 12-in. gate valve was converted to hydraulic operation. The 11-in. bronze cylinder was taken literally from the scrap heap, having previously served as a sleeve bearing of a large marine engine. A four-way cock and float (Fig. 2) make the valve self-closing. The movement of the float is transmitted through a steel cable, stopper, counterweight, and lever to the four-way cock. When the reservoir is full and the float is at its top position, the stopper presses the lever down and the valve closes.

At this stage, water enters the cylinder under 16 ft of head. It may seem that this pressure is too low to close a 12-in. gate valve. Actually, the closing pressure is much higher. As the valve nears its closing position, the pressure at the upstream side rises in accordance

with the performance curve of the centrifugal pump. The water entering the cylinder is taken from the upstream side, the pressure reaching its peak at the closing point.

When the float goes down as water is discharged from the reservoir, the stopper releases the lever, and the four-way cock switches over to its opening position. This takes place approximately 8 in. below top level, corresponding to a discharge of 20,000 gal. The time required for this quantity to flow out of the reservoir is ample to stop the pump and to equalize the pressure in the mains. The operating head of 15 ft 4 in. is sufficient to open the gate valve because the pressure on both sides, upstream and downstream, is equal. Opening or closing the gate valve takes approximately 6 min.

Some features of the hydraulically operated gate valve acting as a float valve are worth mentioning: the valve opens and closes slowly, thereby preventing water hammer; there is no half-closed position or dripping; and the valve is installed outside the reservoir in a position easily accessible for control and maintenance.

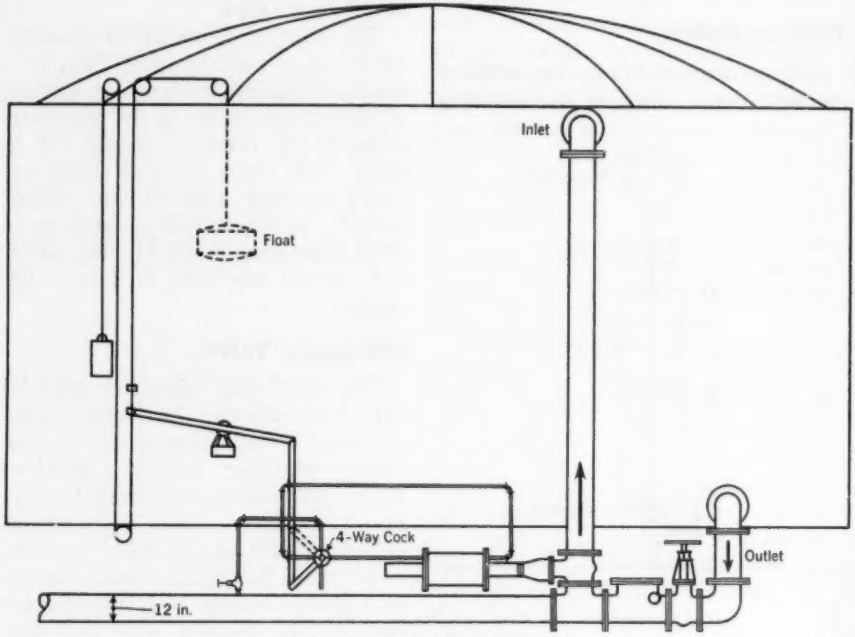

Fig. 2. Self-closing Valve

The float-actuated four-way cock closes the valve when the reservoir is full.

Pollution Control on the Jersey City Watershed

By Robert J. Budrick

A paper presented on Oct. 22, 1953, at the New Jersey Section Meeting, Atlantic City, N.J., by Robert J. Budrick, Prin. San. Engr., Jersey City Water Works, Boonton, N.J.

IN 1904 Jersey City, N.J., started using the Rockaway River and its tributaries as a source of potable water supply and acquired the present Jersey City reservoir, located in Boonton and Parsippany, N.J., from the Jersey City Water Supply Co. Beginning in September 1908, with court permission, this supply was treated with calcium hypochlorite, under the supervision and control of George W. Fuller and George A. Johnson, in an attempt to fulfill a contractual agreement "to deliver a water that was free from pollution deleterious for drinking or other domestic purposes" (*1*). That the experiment proved successful was a monumental fact of tremendous significance to the comfort and well being of the whole world, as public health officials will gladly attest. It was here that chlorination was first used on a a large scale (to treat 40 mgd of water) and as a continuous or permanent method of water purification.

By 1917 a trunk sewer to serve the municipalities on the Jersey City watershed and preserve its water supply was being given serious consideration. Plans and specifications for constructing the intercepting sewer and a sewage treatment plant at Jersey City's expense were prepared, and the latter was completed in October 1924. Owing to the delay caused by the abandonment of the Morris Canal, along which part of the trunk sewer extends, the line was not finished until the middle of 1925.

The sewage treatment plant had a rated capacity sufficient for a population of approximately 20,000 and was considered more than adequate at the time. Since then, however, the towns of Dover and Boonton, the borough of Rockaway, and a small portion of Denville Township have connected their individual collecting systems to the Jersey City intercepting sewer, thus necessitating a plant enlargement program to be described later.

Watershed Maintenance

The Jersey City water supply serves approximately 450,000 persons. The amount of water diverted from the Jersey City reservoir at Boonton ranges approximately from 58 to 65 mgd. The city's watershed is 118 sq miles in area and is served by the Rockaway River and its tributaries (Fig. 1). The impounding reservoir (at Boonton and Parsippany) is owned and operated by the city and has a capacity of approximately 7.5 bil gal. The auxiliary Split Rock Reservoir, north of Boonton, has an additional capacity of 3.2 bil gal. The water flows from this reservoir to the one at Boonton through natural channels, entering the Rockaway River at Denville, by way of Beaver Brook.

In accordance with the recent trend toward decentralization, some industries have removed from large cities to the watershed area, with a consequent growth in residential developments. To anticipate possible pollution, the bureau checks the proposed location of these factories and studies the disposal of trade wastes, if any. From estimates of the probable number of employees, the size of needed sewage disposal facilities is determined. Conferences are held with factory and housing project officials and contractors in order to help them plan their disposal systems. When the factories are located outside the limits of the trunk or lateral sewers, septic tanks

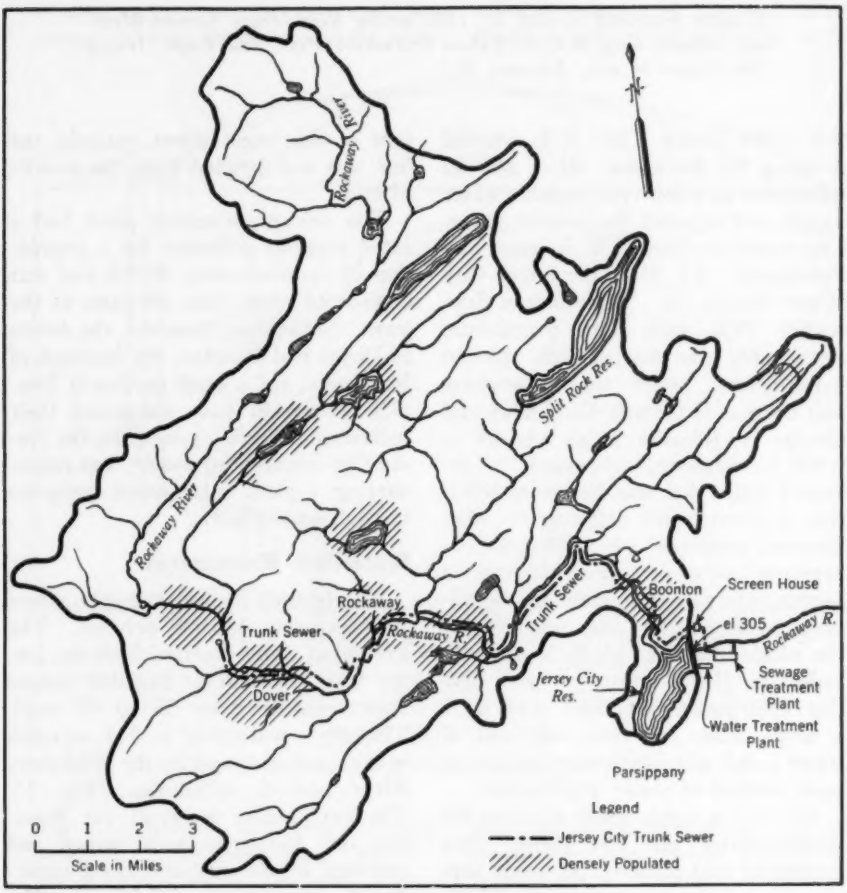

Fig. 1. Jersey City Watershed

The trunk sewer and treatment plant facilities are owned and operated by Jersey City.

with adequate leaching fields must be constructed. The important consideration is that no pollution originating from these fields should drain into any tributaries of the city's potable water supply.

Quality control stations established at key points on the watershed streams give a descriptive picture of the nature of the water in the various sectors. Samples are collected, analyzed, recorded, and compared regularly. The source of a pollution problem can thus be localized in a relatively short time. The effect of this program is reflected in the bacteriological results shown in Table 1.

In the marginal area within a 7-mile radius of the Jersey City reservoir at Boonton, the maintenance crew carries on a reforestation program, cuts over and establishes new fire lanes, cuts brush, and removes fallen and damaged timber. Algae and aquatic growths are removed when they become exposed during the low-water period.

Climatological Records

In order to analyze the problems involved in water conservation and utilization, it was found expedient to establish four weather stations throughout the watershed, so that an average yearly precipitation yield could be determined. The rainfall year is considered to run from October through September, providing a better balance of the seasons than a calendar-year basis would give. A 20-year period of record for each station furnishes data for comparison.

A gaging station to meter the water coming into the reservoir at Boonton has been in existence for many years, making it possible to determine the relationship between runoff and rainfall. In addition, a recording stream gage is located below the reservoir spillway, so that the amount of surplus water can be ascertained. The precipitation figures and flow records give a reasonably accurate picture of the watershed yield and aid in water conservation.

Trunk and Lateral Sewers

The Jersey City trunk sewer serving the watershed is approximately 13.7 miles in extent and is fed by approximately 64 miles of lateral sewers with more than 5,000 individual connections accommodating approximately 30,000 persons. The average inflow from the trunk sewer to the sewage treatment plant at Boonton reached a maximum of 5.19 mgd during 1952.

TABLE 1

Annual Average Bacteriological Results

Year and Location	Bacteria per Milliliter	MPN Coliform Organisms per 100 ml
1951		
Reservoir inlet	273	2,346
Water plant intake	46	51
1952		
Reservoir inlet	392	1,293
Water plant intake	57	107

An inspector is assigned to all construction of new extensions and laterals. It is his duty to see that the work is done according to the plans and specifications submitted, and, in general, to look after the interests of Jersey City. The sewer inspector is also instructed to approve each house connection made to either the trunk or lateral sewer before any backfilling can be done by the contractor. The right of Jersey City to make these inspections was incorporated into the original agreements with the various towns.

Inspection has proved advantageous not only to Jersey City but to the individual taxpayer and property owner as well.

Each town or community must provide for the construction and maintenance of its own laterals, but Jersey City maintains the trunk sewer and handles all the domestic sewage free of charge. Because of the influx of population into the watershed, there is a steady demand for the towns to extend their sewer laterals. The resulting increase in operating load and cost of treatment is offset by the reduction in pollution hazards.

Sewage Plant Enlargement

For the past several years the sewage treatment plant has been operating with an excessive overload. It is planned to increase the rated capacity from 2.5 to 7.5 mgd, and a general contract for this work was awarded in September 1951. Construction on the various units has either been completed or is in progress.

Two new mechanical primary settling tanks have been added to the present battery of tanks, and two high-rate trickling filters have replaced the worn-out contact filters. Two clarifiers have been installed to supersede the overloaded slow sand filters. The clarifiers occupy only the space of two sand filter beds and take the place of sixteen sand filters which covered 6 acres. A large new contact tank helps to take care of the increased flow and provides a longer detention period.

A sludge disposal building was constructed to heat raw and digested sludge externally and recirculate it until the desired temperature is obtained. Vacuum filters were installed to dewater the digested sludge. An overflow detention building was built to meet flood conditions, and an automatic chlorinator has been erected to feed during the detention period.

A new administration building has also been completed. The ground floor will house motorized equipment, a repair shop, and locker and washroom facilities for the employees. The second story has a modern laboratory and engineering offices. The plant enlargement program represents a major step forward in Jersey City's effort to control pollution.

Personnel

A total of 57 persons are assigned to the watershed protection program. They include the engineer in charge, his assistant, chemists and laboratory technicians, clerks, watershed and sewer inspectors, water and sewage treatment plant operators, foremen, maintenance men, laborers, reservoir patrolmen, groundskeepers, and drivers. The maintenance and labor crews are shifted from project to project as needed.

By providing sewage and waste disposal facilities on its watershed, Jersey City insures that water of high quality is delivered to the water plant, where only chlorination is required. Users of water for both drinking and other purposes are thus able to obtain a suitable supply.

Rererence

1. LEAL, J. L. The Sterilization Plant of the Jersey City Water Supply Co. at Boonton, N.J. *Proc. AWWA*, p. 100 (1909).

Theoretical Principles of Aeration

By Paul D. Haney

A contribution to the Journal by Paul D. Haney, San. Engr. Director, San. Eng. Center (formerly Environmental Health Center), US Public Health Service, Cincinnati, Ohio.

AERATION of water is an example of a useful class of industrial processes involving mass transfer between phases. In water works practice, one phase is always water and the other is a gas, usually air, but occasionally a mixture of air and other gases. As applied to water treatment, the term "aeration" may be defined as a process whereby the water is brought into intimate contact with a gas, usually air, for the purpose of transferring highly volatile substances to or from the water. These substances may include oxygen, carbon dioxide, nitrogen, hydrogen sulfide, methane, and various unidentified volatile organic compounds responsible for taste and odor. Oxygen, nitrogen, and carbon dioxide are universally present in air, and all the substances previously named are encountered in various natural waters. Carbon dioxide may also be introduced by such treatment methods as coagulation.

The addition of chlorine to water might be considered to fall within the scope of this definition. Although certain of the principles of aeration apply, chlorination is accomplished by highly specialized equipment. Consequently, the process is not considered pertinent to this discussion. Recarbonation (addition of carbon dioxide) of a softened water is another treatment method not ordinarily classed as an aeration process; it is fundamentally similar, however, and is often accomplished with equipment like that used in certain types of aerators. Aeration finds its greatest application in the absorption and release of gases, principally oxygen and carbon dioxide.

Aerator Types and Uses

On the basis of present practice, structures or equipment for aeration may be classified into two general types: [1] *waterfall* aerators (examples: spray nozzles, cascades, multiple trays); and [2] *injection* aerators (example: bubbles of compressed air passed through the water). The waterfall type accomplishes aeration by causing the water to break into drops or thin layers, thereby increasing the ratio of exposed area to volume. The injection type (also called "bubble" or "diffusion" aerators) discharges bubbles of air into the water through special injection devices such as perforated pipes or porous plates. Inasmuch as "diffusion" is a well recognized natural phenomenon applicable to both kinds of aerators and to various other processes of mass transfer, the adjectives "injection" or "bubble" are preferable as descriptive terms for this type of aeration.

The basic purpose of aeration is the improvement, directly or indirectly, of the chemical and physical characteristics of water for public and industrial supply. Improvement by aeration may be obtained through the physical removal of:

1. Taste- and odor-producing substances such as hydrogen sulfide and, to a limited extent, certain volatile organic compounds.
2. Corrosive substances such as carbon dioxide, hydrogen sulfide, and, in many industrial water supplies, oxygen. (Removal of oxygen is, of course, a deaeration process.)
3. Substances that consume or interfere with chemicals used in subsequent treatment—for instance, carbon dioxide before lime softening and hydrogen sulfide before chlorination.
4. Methane, which might create an explosion hazard if left in the water.

Aeration may also be used for the addition of:

1. Oxygen for the improvement of taste and odor and for the subsequent oxidation of iron, manganese, hydrogen sulfide, and, to a limited extent, organic matter.
2. Carbon dioxide for the recarbonation of softened waters and for assistance in hydrogen sulfide removal.

As applied to water in streams or lakes, the process of dissolved-oxygen absorption, generally termed "reaeration" or "reoxygenation," is fundamentally the same as the aeration process used at a water treatment plant and may be looked upon as a special case under the broad heading of gas absorption. In polluted water, the mechanism is complicated by the oxygen demand of the pollutants, ordinarily not an important factor in water works aeration. The phenomenon of reaeration of natural bodies of water has been widely studied because of its vast importance in connection with water pollution problems (*1–3*) and will not be given specific consideration in this paper.

Aeration Studies

This examination of the theoretical principles of aeration will be limited largely to the addition and removal of oxygen and carbon dioxide. Quantitative discussion of the theory of removal of taste- and odor-producing substances by aeration is limited by uncertainty about the nature and behavior of the minute amounts of the compounds involved. Recent work reported by Middleton, Braus, and Ruchhoft (*4*) may lead, after further research, to a better understanding of the whole problem of taste and odor in water.

The mechanism of the transfer of gases between gas and liquid phases has been studied by Adeney and Becker (*5, 6*); Whipple, Fair, and Whipple (*7*); Roe (*8*); Lewis and Whitman (*9*); Baylis (*10*); Nordell (*11*); Powell (*12*); and numerous other investigators (*13–21*) representing various fields of interest. A good bibliography containing references to much of the important work done prior to 1930 has been prepared by Baylis (*10*).

Probably of greatest interest to the water works profession is the Baylis (*10*) discussion of aeration, for it is presented from a water treatment standpoint. Many other investigators have published excellent articles and experimental data that have contributed much toward a better comprehension of the aeration process. Their reports, however, have been largely

concerned with applications to the process industries or sewage treatment (*18, 21*), the greatest amount of study being devoted to the injection or bubble type process of gas transfer.

The chemical industry generally terms the addition of gas to a liquid "absorption" and frequently speaks of the removal of gas from a liquid as "desorption" or "stripping." Theoretically, the latter may be looked upon as "negative absorption." The theory of absorption of gases, which has been quite well developed (*22*) and widely employed, may be assumed to apply as well to the release of gases from water (*9, 10, 22*).

Fundamental Concepts

Before the theory of the aeration process can be developed, it is necessary to consider several important physicochemical principles, including equilibrium, gas solubility, diffusion, and the properties of a gas-liquid surface (interface).

Equilibrium

As applied to dissolved gases, "equilibrium" means no further change in concentration of the dissolved gas with the passage of time. Considered from the standpoint of gas transfer, aeration implies the promotion of equilibrium between the gaseous constituents of water and those of the atmosphere (*23*). Water exposed to air tends to reach equilibrium with it; the function of aeration is to speed up this natural process. True equilibrium is mainly of theoretical interest, as it is frequently impractical and generally unnecessary to achieve it. Nevertheless, equilibrium or saturation concentration is an important concept because the difference between the equilibrium concentration (saturation value) of a gas and its actual concentration is the driving force available to cause interchange of gas between air and water. If a water is not saturated with oxygen when in contact with air, oxygen will go into solution and equilibrium will gradually be approached from the direction of undersaturation toward saturation. On the other hand, if the water contains more oxygen or, as more frequently happens, more carbon dioxide than the amount that corresponds to saturation when exposed to air, oxygen or carbon dioxide will be released, and equilibrium will be approached from the direction of supersaturation. Agitation of the water—that is, aeration—by stirring, by breaking the water into drops or thin layers, or by blowing bubbles of air through it, will speed up this process. The best that aeration can accomplish is the acceleration of a process which goes on naturally. As previously stated, it may not be possible to establish exact equilibrium with any reasonable amount of aeration, but it can often be approached.

Solubility of Gases

Like solids, each gas has its own solubility characteristics. The factors governing gas solubility in water are temperature, pressure, dissolved solids in the water, and the chemical nature of the gas. Unlike many solids, gases exhibit decreasing solubility with increasing temperature. For pressures up to approximately 1 atmosphere (atm) and for gases which do not react chemically with water to any great extent, the mass of the gas which will dissolve in water at a given temperature is directly proportional to the partial pressure of the gas in contact with the water (*24*). Under conditions of

equilibrium and constant temperature, this relationship, called Henry's law, may be expressed by the equation:

$$S = HP \quad \ldots\ldots\ldots (1)$$

in which S is the concentration of gas in the water, at equilibrium; P is the *partial* pressure of the particular gas in the air or other gas in contact with the liquid; and H is the Henry's law solubility coefficient.*

Henry's law applies to the gases most frequently considered in connection with the aeration of water: oxygen, nitrogen, methane, and carbon dioxide. The last reacts with water to form carbonic acid (H_2CO_3), which ionizes as follows:

$$H_2CO_3 \leftrightharpoons H^+ + HCO_3^-$$
$$HCO_3^- \leftrightharpoons H^+ + CO_3^{--}$$

At ordinary water temperatures and at the concentrations of carbon dioxide encountered in natural waters, however, less than 1 per cent of the dissolved gas will be in the form of H_2CO_3 (*9, 25*). Furthermore, the H_2CO_3 ionization constants are extremely low. Hydrogen sulfide, which is encountered in certain ground water supplies, also undergoes chemical reactions in water. The dissolved H_2S will ionize to a slight extent:

$$H_2S \leftrightharpoons H^+ + HS^-$$
$$HS^- \leftrightharpoons H^+ + S^{--}$$

H_2S will also react with alkaline constituents in natural waters, so that much of it may be present as sulfide ion, S^{--}, rather than as H_2S (*11, 26*). Henry's law does not apply closely to the more soluble gases, such as chlorine and ammonia, which readily form compounds with water, but these gases are not of great significance for aeration.

Dissolved solids such as salts lower the solubility of gases in water. For example, the equilibrium concentration (20°C, 1 atm) of oxygen dissolved in sea water (20,000 ppm chlorides) is 7.42 ppm, compared with 9.17 in zero-chloride water (*27*). The lowering of gas solubility by dissolved solids, however, is of minor importance in most water supplies. Temperature and pressure are the major factors governing gas solubility in most natural waters. Pressure effects can be estimated by Henry's law, as already indicated. Although there is no simple relationship between temperature and solubility, adequate tables of data showing gas solubility at various temperatures are available (*11, 27, 28*).

It should be evident that it is not correct to speak of the solubility of a gas in water without specifying temperature and pressure. In practice, however, the partial pressures of oxygen and carbon dioxide in air are frequently assumed to be reasonably constant at approximately 21 per cent by volume or 0.21 atm and 0.035 per cent by volume or 0.00035 atm, respectively (*11*). Pure water at 20°C (68°F) exposed to air at a pressure of 1 atm and in equilibrium with it will contain 9.17 ppm of dissolved oxygen and 0.5 ppm of dissolved carbon dioxide. These are the *saturation values* of the two gases at the specified temperature and the indicated partial pressures. The saturation value for a gas is its equilibrium concentration for the specified conditions. The saturation values for CO_2 and O_2 (20°C) are usually assumed to be those previously given. It must always be remembered, however, that these and other saturation values at other temperatures can differ appreciably from published values if the partial pressures of the gases change. The partial pressure of oxy-

* If S is in parts per million and P is in atmospheres, H will be in ppm/atm.

gen, for example, becomes lower with increased altitude, while the CO_2 content in air may rise from 0.035 per cent in the country to 0.06 per cent in an industrial area (*11*). Most published data are in terms of gas solubility in distilled water. Enough dissolved salts may be present in some natural waters to require a significant correction (*27*).

Diffusion

A few large crystals of copper sulfate placed in a glass of water will sink to the bottom and slowly go into solution. If the water is not mixed by stirring or by thermal currents, the layer of blue-colored copper sulfate solution will remain in the bottom of the glass for some time. After a while, without any apparent mixing whatsoever, the color of the water will become uniform throughout, indicating uniform concentration of copper ion. This slow mixing of the copper sulfate with all the water in the glass results from the process of diffusion. Evidently diffusion tends to produce a stable state of uniform concentration. Water flows through a pipe from a point of high head to one of low head at a rate proportional to the square root of the head difference. Heat flows by conduction from a point of high temperature to one of low temperature at a rate proportional to the temperature difference. In the former instance, the driving force is a function of the difference in head; in heat flow, the drive is furnished by the temperature difference. In diffusion, the "drive" is the *concentration difference* of the substance being diffused. When dealing with water and heat flow, head and temperature variations per unit of length are termed hydraulic and temperature gradients, respectively. For diffusion, this same measure is the "concentration gradient."

The rate of molecular diffusion of a dissolved gas in a liquid is dependent on the characteristics of the gas and liquid, the temperature, the concentration gradient, and the cross-section area through which diffusion occurs. These various factors may be combined into a differential equation of diffusion, which is often termed Fick's law (*29*):

$$\frac{dm}{dt} = -DS\frac{dc}{dx} \quad \ldots\ldots (2)$$

in which $\frac{dm}{dt}$ is the time rate of mass transfer by diffusion; S is the cross-section area through which diffusion occurs; $\frac{dc}{dx}$ is the concentration gradient (mass per unit volume per unit of length) in the direction perpendicular to the cross-section area; and D is a constant characteristic of the solute and solvent at a given temperature, called the "diffusion coefficient." (D is expressed as area per unit time—for example, square centimeters per hour.)

This equation is fundamentally the same as that used to describe the performance of all types of aerators (Eq 5, page 362). The similarity is due to the fact that molecular diffusion through films at the water surface largely controls aerator performance. Application of a diffusion equation to reaeration has been discussed by Velz (*30*).

Surface Properties

It is evident from what has been presented previously that "equilibrium or saturation represents the ultimate state" (*9*) which water exposed to air or some other gas tries to assume, and that equilibrium is a characteristic of primary importance to the aeration process. The second important char-

acteristic of the aeration process—and one which will be extensively considered in this paper—is the rate at which the water approaches equilibrium. Equilibrium and rate of approach to it are not independent of one another, for, under comparable conditions, the driving force (and, hence, the rate of approach) is greater the further the system is from equilibrium.

One of the important factors affecting this rate of approach to equilibrium or saturation is the formation of films at the water-air surface which offer resistance to gas transfer. The surface film is roughly analogous to a thin layer of oil floating on the surface of a body of water which is subjected to agitation. If the oil spreads uniformly, it will form an effective seal even though there is considerable turbulence in the water body (Fig. 1).

An air-water surface or interface exhibits properties that are strikingly different from those of the main body of water or air. There is evidence (*31*) that when a water-air (or other liquid-gas) surface is formed, molecules at the interface become oriented into a definite pattern, thus losing the free and aimless movement characteristic of the molecules of the main body of the gas and liquid. These films of oriented molecules constitute an important barrier to the transfer of gas to or from the water. Evidence has been found which indicates that the extent of molecular orientation at the surface is sufficient to produce a noticeable effect on the characteristics of the surface region. The orientation increases with increasing dissymmetry of the molecules involved and decreases with increasing temperature (*31*). The oriented molecules probably do not mix with the rest of the gas or water, even if the water and gas are in a state of turbulence (*10*).

Ippen and others (*32*), in describing work on bubble aeration, refer to experiments in which the fact that a film of water is carried along with the bubble in its ascent (through water) was demonstrated by allowing the bubble to penetrate a mineral oil layer at the top of the water column. Water could be seen draining off the bubble, and attempts were made to measure the amount of water in order to calculate the liquid film thickness.

Bartholomew and colleagues (*17*), in discussing oxygen transfer through air bubbles or other air-liquid interfaces, state that the diffusion resistance was found to be located in the liquid phase and that its magnitude depends upon the presence of adsorbed surface-active material at the interface. It seems probable that soaps, detergents, organic acids, and many other substances, even when present in water in minute amounts, would be capable of causing considerable resistance to gas transfer through their influence on the characteristics of the air-water interface. Kehr (*33*) presented data showing the adverse effects of a variety of materials (oils, soaps, organic acids,

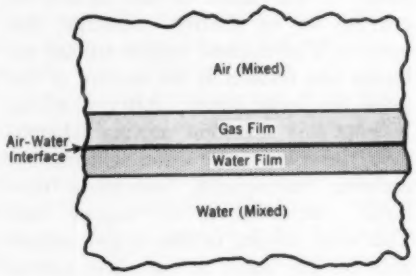

Fig. 1. Gas and Water Films

"Films" of molecules oriented into a definite pattern form at the gas-water interface and constitute a barrier to the transfer of gas to or from the water.

and raw and treated sewage) on the rate of transfer of atmospheric oxygen to water. In Kehr's experiments 6 ppm of soap in water in an aeration test channel reduced the reaeration rate approximately 50 per cent.

There is little doubt that film-forming substances are present in all natural waters and in air. The passage of gas through these gas and liquid films must be by the very slow process of gaseous and liquid diffusion. Turbulence apparently lowers film resistance, as does increased temperature. A high velocity gradient across the interface has a similar effect.

Film "thickness," a useful means of visualizing resistance to gas transfer, can be calculated from absorption data. The thickness of a quiescent water film has been estimated to be of the order of 0.2 cm (*9, 10*). On the other hand, a falling drop of water which has a high velocity gradient across the interface has been estimated to have a film thickness of the order of 0.0003 cm (*10, 25*). The relative film thickness or aeration resistance values are more important than the absolute values. The comparative film thickness or resistance of water at rest and a falling drop is approximately 700:1. The film thickness is believed to increase with exposure time (*10*).

One set of experiments by Adeney and Becker (*5, 9*) gave data which indicated a water film thickness of 0.001 cm for rising bubbles—approximately four times that of falling drops, using a comparable calculation method (*9, 10*). Computations based on Ippen's recent experiments with small air bubbles (*32*) gave lower film thickness or resistance values (see Table 2, page 367).

Surface tension is another property of considerable interest and importance in aeration processes. Fluid surfaces exhibit certain features of a stretched elastic membrane. When air and water are in contact, the inequalities of molecular attraction (cohesion) at the water surface, together with other forces, change the shape of the surface to produce a minimum potential energy value (*29*). For example, an oil drop suspended and at rest in a liquid of the same density as the oil assumes a spherical shape as a result of the force of surface tension. On the other hand, a drop of water hanging from a faucet or the end of a pipet takes on a pear shape because it is acted upon by the forces of both surface tension and gravity. Surface tension plays a part in drop formation and is a very important factor in the formation of air bubbles in water.

Gas Transfer Rate

Adeney (*5, 6*), as a result of studies of bubble aeration, proposed the following equation to describe the solution of oxygen and nitrogen in water from fairly large bubbles:

$$w = w_1 - (w_1 - w_0)e^{-f(a/v)t} \quad . \quad (3)$$

in which w is the concentration in the water at the end of t min; w_1 is the saturation concentration at the given temperature and pressure; w_0 is the initial concentration ($t = 0$); f is the coefficient of escape of gas from the water per unit of area (varies with temperature); v is the volume of the water; a is the area of surface exposed; and e, the base of natural logarithms, is equal to 2.718. The Adeney equation may also be written:

$$\log_{10} \frac{w_1 - w}{w_1 - w_0} = -\left(\frac{f}{2.303}\right)\left(\frac{a}{v}\right)t \quad . \quad (4)$$

One of the best analyses of the gas absorption process is that provided by Lewis and Whitman (*9, 34*). Methods of applying the original Whitman

two-film theory have been gradually developed and refined in the 30-year period since the theory was proposed. Despite the fact that the theory has never been completely checked experimentally (*22*), it is highly useful in the design of gas absorption or release devices.

Evidence of the probability of the existence of films at the water-air surface has already been presented. Applied to aeration of water, the theory involves consideration of the resistance to mass transfer offered by these two films at the air-water interface. The films are present regardless of the type of aerator used, but they may vary in their effect, depending on the particular situation. Conditions at the gas-water interface are determined by the equilibrium existing between gas and liquid concentrations and by the fact that all of the gas diffusing through either film must also diffuse through the other (*9*). (Obviously, there can be no accumulation of gas at the interface beyond that corresponding to saturation.) Figure 2 shows diagrammatically how the concentration changes as equilibrium conditions are approached. Figure 3 depicts an air-water interface—such as would be formed by a water drop, a water layer, or an air bubble in water—and the concentration gradients. The drawings do not purport to show the relative film thickness or molecular shape or orientation. They merely offer highly diagrammatic presentations of surface conditions which apparently have a major influence on gas transfer. The resistance encountered by diffusing gas molecules is due to collisions with the molecules of the gas or liquid through which diffusion is occurring. As the molecules are much closer together in water than in air, diffusional resistance will be greater in the former.

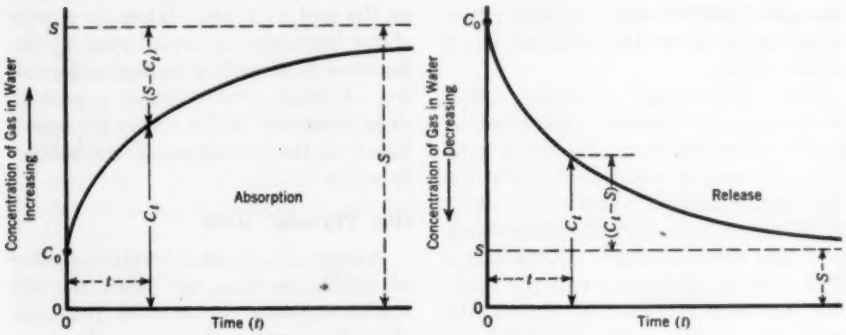

Fig. 2. Gas Absorption and Release

S is the saturation concentration of the gas in water; C_t, *the concentration at any time,* t; *and* C_0, *the initial concentration* $(t=0)$. *For gas absorption, as* t *increases,* $C_t \rightarrow S$ *and* $(S-C_t) \rightarrow 0$; $(S-C_t)$ *represents the "driving force." For release (negative absorption), as* t *increases,* $C_t \rightarrow S$ *and* $(C_t-S) \rightarrow 0$; (C_t-S) *represents the "driving force." Conditions of constant temperature and air pressure are assumed.*

Resistance is also a function of film thickness, however, and the gas film will probably be somewhat thicker than the liquid film because, under comparable conditions of turbulence, the film thickness is determined by the kinematic viscosity, which is greater for gases than for liquids (9). In spite of the greater thickness of the gas film, it offers less diffusion resistance to slightly soluble gases such as oxygen and carbon dioxide than does the liquid film. The less soluble gases diffuse so slowly through the liquid film that only a small concentration difference is required across the gas film. The liquid at the interface will therefore be substantially saturated with the gas solute at the partial pressure (P_g) of the gas. It is unnecessary to consider the gas film further in the calculations when slightly soluble gases like oxygen or

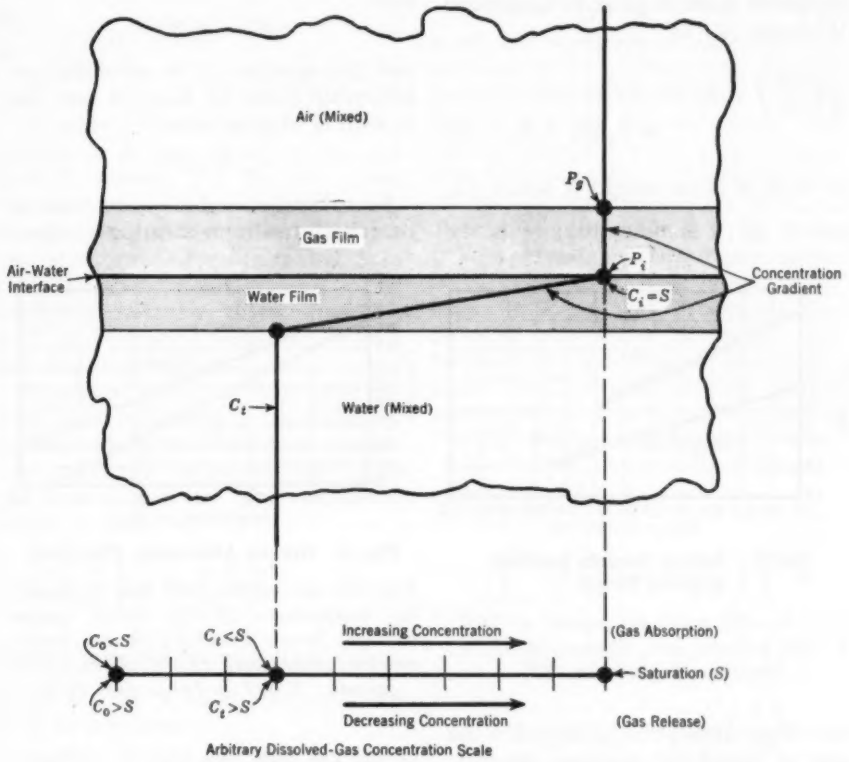

Fig. 3. Absorption or Release of Slightly Soluble Gas

The concentration gradient in the water film is large, compared with that in the gas film. (See text for explanation of symbols.)

carbon dioxide are involved. (This statement would not hold true for a highly soluble gas such as ammonia.)

Aeration Equations

The fundamental gas absorption equation applicable to the addition of oxygen to water is given by Lewis and Whitman (*9*) as:

$$\frac{1}{A}\left(\frac{dw}{dt}\right) = k_L(C_i - C_L) = k_g(P_g - P_i) \quad . . (5)$$

in which w is the weight of solute dissolved (g); t is time (hr); $\frac{dw}{dt}$ is the rate of gas absorption (g/hr); A is the area of liquid-gas interface (sq cm); k_g is the transfer coefficient through the gas film (g/sq cm/hr/atm); k_L is the transfer coefficient through the liquid film (cm/hr); P is the concentration of solute in the gas (atm); C is the concentration of solute in the liquid (g/ml); and subscripts i, g, L apply to conditions at the interface, in the main body of gas, and in the liquid, respectively. It should be noted that this and other related aeration equations can apply with exactitude only to gas transfer under conditions of constant temperature and pressure and in the absence of appreciable chemical reaction (*9*).

At the true interface between liquid and gas, substantial equilibrium exists (P_i is in equilibrium with C_i). Therefore:

$$C_i = f(P_i)$$

and this function is the solubility relationship given by Henry's law (Eq 1, with H in g/ml/atm):

$$C_i = HP_i$$

For slightly soluble gases, there is practically no concentration gradient in the gas film (see Fig. 3). Therefore:

$$P_i = P_g$$

and:

$$C_i = HP_g$$

For this case (negligible gas film resistance), the following equation, in which K_L represents the overall (both films) gas transfer coefficient, is also valid:

$$k_L = K_L$$

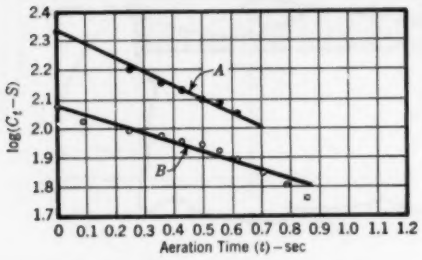

Fig. 4. Carbon Dioxide Removal (Falling Drops)

Key: A—*200 drops per minute at 20°C;* B—*300 drops per minute at 16°C. Based on Baylis data (10).*

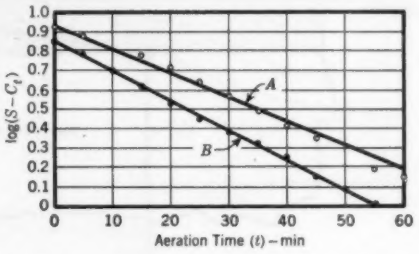

Fig. 5. Oxygen Absorption (Bubbles)

Key: A—*air bubbles 1.29 mm in diameter, temperature 20.6°C, 144-in. water column;* B—*air bubbles 1.38 mm in diameter, temperature 23.8°C, 86-in. water column. Based on Ippen data (32).*

Equation 5 may therefore be written:

$$\frac{1}{A}\left(\frac{dw}{dt}\right) = k_L(C_i - C_L) = K_L(C_i - C_L)$$

or:

$$\frac{dw}{dt} = k_L A(C_i - C_L) = K_L A(C_i - C_L)$$

C_i represents the equilibrium concentration in the liquid at the gas partial pressure, P_g, for any given temperature. As previously noted, this is the saturation value of the gas and is subsequently designated S in the equations for gas transfer. The similarity between these equations and the diffusion equation (Fick's law, Eq 2) is evident.

Equation 5 may be somewhat revised as to nomenclature, and also rewritten, on the basis of rate of concentration change, by dividing both sides of the equation by the volume of water, V (ml):

$$\frac{1}{V}\left(\frac{dw}{dt}\right) = k_L\left(\frac{A}{V}\right)(S - C_t)$$

As $\frac{w}{V}$ represents concentration (g/ml, equal to ppm $\times 10^{-6}$), this equation may be rewritten:

$$\frac{dC_t}{dt} = k'\left(\frac{A}{V}\right)(S - C_t) \ldots (6)$$

in which S is the saturation concentration of the gas in water (ppm); C_t is the concentration (ppm) of gas in the water at any time t; and $k' = k_L \times 10^{-6}$. Any concentration units may be chosen for S and C_t but "parts per million" is a convenient term in connection with water aeration.

In gas absorption, C_t is less than S; in gas release, C_t is greater than S. Assuming that gas release is "negative absorption," Eq 6 may be revised to describe the rate of gas release:

$$-\frac{dC_t}{dt} = k'\left(\frac{A}{V}\right)(C_t - S) \ldots (7)$$

The value $\frac{dC_t}{dt}$, in either absorption or release, represents an instantaneous rate and is not applicable to any appreciable time period, because, as time elapses and gas transfer occurs, the value of $(S - C_t)$ or $(C_t - S)$ changes. The curves in Fig. 2 indicate this change diagrammatically for both gas absorption and release.

To determine concentration changes for a given time, it is necessary to integrate Eq 6 and 7 between the limits of zero and t for "time" and between C_0 and C_t for "concentration." (C_0 corresponds to initial concentration; that is, $C_t = C_0$ when $t = 0$.) For gas absorption:

$$\frac{dC_t}{S - C_t} = k'\left(\frac{A}{V}\right)dt$$

$$-\int_{C_0}^{C_t} \frac{-dC_t}{S - C_t} = k'\left(\frac{A}{V}\right)\int_0^t dt$$

$$\log_e \frac{S - C_t}{S - C_0} = -k'\left(\frac{A}{V}\right)t$$

$$\log_{10} \frac{S - C_t}{S - C_0} = \frac{-k'}{2.303}\left(\frac{A}{V}\right)t$$

$$= -k\left(\frac{A}{V}\right)t \ldots (8)$$

$$k = \frac{k'}{2.303} = \frac{(k_L)(10^{-6})}{2.303}$$

or:

$$C_t = S - (S - C_0)10^{-k(A/V)t} \ldots (9)$$

This is essentially the same as Eq 4, developed by Adeney (*5*, *6*).

For gas release the integrated equation is:

$$\log_{10}\frac{(C_t - S)}{(C_0 - S)} = -k\left(\frac{A}{V}\right)t \quad (10)$$

For any situation where $\left(\frac{A}{V}\right)$ is constant, Eq 8 (absorption) and Eq 10 (release) may be reduced to Eq 11 and 12, respectively:

$$\log_{10}\frac{S - C_t}{S - C_0} = -k_A t \quad (11)$$

$$\log_{10}\frac{C_t - S}{C_0 - S} = -k_A t \quad (12)$$

in which k_A is $k\left(\frac{A}{V}\right)$.

The previously presented equations, especially the differential equations, Eq 6 and 7, indicate that:

1. At any instant, the rate of gas transfer is directly proportional to the difference between the gas saturation concentration (S) and the actual concentration (C_t) in the water (see Fig. 2).

2. The rate of gas transfer (concentration units) is directly proportional to the exposed area–volume ratio $\left(\frac{A}{V}\right)$; thus, for a given volume, increasing the area exposed will produce a proportionate increase in the rate of gas transfer.

3. The rate of gas transfer is directly proportional to the gas transfer coefficient (k_L or K_L), which is, in turn, dependent on the diffusivity of the gas in question and on the film resistance.

4. The total amount of gas transfer rises as the period of aeration increases (Eq 8 and 10).

5. The percentage change in the gas saturation deficit ($S - C_t$) or surplus ($C_t - S$) for any given period is constant, based on the deficit or surplus at the beginning of the period (Eq 6 and 7).

6. Temperature and pressure are important factors because they influence gas solubility (S). Temperature also influences diffusivity and film resistance and, hence, the value of k_L.

7. If the performance of an aerator in absorbing or releasing gas is known for one set of conditions, its performance under other conditions may be approximated. (For example, an estimate of the effect on CO_2 removal of doubling the aeration time by the installation of duplicate equipment in series with that existing can readily be made, provided the performance of the existing installation is known.)

Equations 8 and 10, which describe absorption and release, may be rewritten as Eq 13 and 14, respectively:

$$\log_{10}(S - C_t) = -k\left(\frac{A}{V}\right)t + \log_{10}(S - C_0) \quad (13)$$

$$\log_{10}(C_t - S) = -k\left(\frac{A}{V}\right)t + \log_{10}(C_0 - S) \quad (14)$$

Both of these can be considered to represent the equation of a straight line, $y = mx + b$, provided functions of y and x are assigned as follows:

$$y = \log_{10}(S - C_t) \text{ [absorption]}$$
$$y = \log_{10}(C_t - S) \text{ [release]}$$
$$x = t$$

The slope (m) and the y-axis intercept (b) are defined by:

$$m = -k\left(\frac{A}{V}\right)$$

$$b = \log_{10}(S - C_0) \text{ [absorption]}$$
$$b = \log_{10}(C_0 - S) \text{ [release]}$$

If these equations are valid for aerator performance, experimental data appropriately plotted will yield straight lines. The lines shown in Fig. 4 and 5 indicate substantial conformance.

Gas Exchange Rate Factors

The factors influencing the rate of gas exchange include temperature, extent of agitation, film thickness, gas partial pressure, and depth of basin.

Temperature

Changes in temperature are important, and it is essential that a careful distinction be made between the effect of temperature on equilibrium (gas saturation value, S) and its effect on the gas transfer coefficient (k_L), which is a measure of the rate of approach to equilibrium. Increasing the temperature makes the gas less soluble (decreases S), thus *lowering* the rate of absorption (Eq 8) but *increasing* the rate of release (Eq 10). The gas transfer coefficients, on the other hand, increase with increasing temperature, thus making both absorption and release more rapid at higher temperatures for a given saturation deficit, $(S - C_t)$, or surplus, $(C_t - S)$. The increase in the gas transfer coefficient with temperature is due to decreased resistance plus an increase in the true coefficient of diffusion, D (Fick's law, Eq 2).

Agitation

Agitation of the liquid decreases gas transfer resistance. The effects of agitation on the gas absorption coefficient (k_L) have been studied by numerous investigators. Results reported by Hutchinson and Sherwood (*25*) indicate that the absorption coefficient varies approximately as the 0.6 power of the stirring speed above approximately 100 rpm.

Mixing is also important because it minimizes the concentration gradients within the main body of water. The film theory will have its most precise application when conditions on both sides of the air-water surface are turbulent (*9*), as generally happens in the aeration of water. Bubble aeration produces mixing, and there is evidence of circulation of liquid within falling drops due to the persistence of motion originating in the spray nozzle (*22*). Adequate ventilation, natural or artificial, should be provided to insure air turbulence and for other reasons cited in a subsequent section of this paper.

The highest values of k_L (the thinnest films) are apparently encountered just after the formation of a bubble or drop. This phenomenon has been noted by Whitman (*35*), Baylis (*10*), and Ippen (*32*). (See Table 1, water drops:)

Theoretical considerations led to the conclusion by Pasveer (*37*) that "the rate of diffusion is a maximum at the moment of formation of the oxygen-water interfacial surface . . ." and that "the energy employed for aeration should be directed toward the creation of a new water-air interfacial surface."

Gas transfer coefficients for various experimental conditions are shown in Table 1. The diversity of experimental procedures, however, makes it virtually impossible to compare the various aeration systems solely on the basis of reported gas transfer coefficients (k_L).

Film Thickness

Film "thickness" may be considered an overall measure of resistance to gas transfer. From experimentally obtained values of k_L, the apparent thickness of water films under various conditions may be estimated. Computed film thicknesses, based on gas diffusivity data for oxygen and carbon dioxide in water, given by Wilke (*38*), are presented in Table 2.

The diffusion coefficients (D), according to Wilke, are 1.75×10^{-5}

TABLE 1

Gas Transfer Coefficients

No.	Gas	Temp. °C	Conditions	Gas Transfer Coefficient (k_L) cm/hr	Investigator and Reference
			Absorption Into 50-ml Stirred Water		
1	O_2	25	no stirring	0.41	Hutchinson (*25*)
2	O_2	25	stirring—76 rpm	1.20	Hutchinson (*25*)
3	O_2	25	stirring—171 rpm	3.00	Hutchinson (*25*)
4	O_2	25	stirring—486 rpm	5.43	Hutchinson (*25*)
5	O_2	25	stirring—1,025 rpm	7.64	Hutchinson (*25*)
6	air	20	O_2 from air; no stirring	0.4	Becker (*25*)
			Absorption Into 50-ml Stirred Water		
7	CO_2	25	no stirring	1.46	Hutchinson (*25*)
8	CO_2	25	stirring—93 rpm	1.65	Hutchinson (*25*)
9	CO_2	25	stirring—140 rpm	2.22	Hutchinson (*25*)
10	CO_2	25	stirring—171 rpm	2.73	Hutchinson (*25*)
11	CO_2	25	stirring—486 rpm	4.84	Hutchinson (*25*)
12	CO_2	25	stirring—1,025 rpm	8.35	Hutchinson (*25*)
			Gas Bubbles in Water		
13	O_2	25	10-ml bubbles through water column	20	Schwab (*25*)
14	O_2	25	side of 15-ml bubble	31	Adeney (*25*)
15	O_2	21–22	1.52–2.54-mm diameter bubbles through 25-in. water column	97	Ippen (*32*)
16	O_2	20–21	1.51–2.13-mm diameter bubbles through 140-in. water column	88	Ippen (*32*)
17	air	25	O_2 absorption from tip of 15-ml air bubble through water column	230	Adeney (*25*)
18	air	25	O_2 absorption from side of 15-ml air bubble	32	Adeney (*25*)
19	air	15	O_2 absorption from 0.24-cm diameter air bubble through 34-cm water column	140	Scouller (*25, 36*)
20	air	22	O_2 absorption from 1.33-mm diameter air bubbles through 25-in. water column	205	Ippen (*32*)
21	air	20–22	O_2 absorption from 1.29–2.05-mm diameter air bubbles through 140-in. water column	120	Ippen (*32*)
			Water Drops		
22	CO_2	24	0.1-ml water drops through gas	260	Whitman (*35*)
23	CO_2	24	drops at time of formation	338	Whitman (*35*)

sq cm per second (0.062 sq cm per hour) for carbon dioxide (18°C) and 2.6×10^{-5} sq cm per second (0.094 sq cm per hour) for oxygen (25°C). Inasmuch as most of the data for k_L are at 25°C, the diffusion coefficient for carbon dioxide was corrected to this temperature by the method proposed by Wilke (*38*) and others (*22*). Film thickness or gas transfer resistance was found by dividing D (in square centimeters per hour) by k_L (in centimeters per hour), giving a quotient in centimeters.

The relative thicknesses or resistance values are more significant than the actual values. Drops apparently have the least resistance, but this conclusion is based on limited data. Performance and related data under conditions existing in drop-producing waterfall aerators are not available.

Gas Partial Pressure

In addition to temperature, the partial pressure of the gas in the air surrounding the aerator influences the saturation value of the gas in question. An increase in the partial pressure of the gas in the air will produce a proportional increase in the value of S, a result that would be beneficial for gas absorption (Eq 8) but disadvantageous for gas release (Eq 10). The oxygen partial pressure could be increased significantly by adding pure oxygen to the air supplied to an enclosed waterfall or bubble aerator, or by compressing the air as in the latter type. (A decrease in the partial pressure of oxygen in an enclosed aerator may be prevented by adequate ventilation, but oxygen pressure cannot be raised to any great extent by ordinary ventilation.) The only method of in-

TABLE 2

Film Thickness

No. (Table 1)	Gas	Temp. °C	k_L cm/hr	D sq cm/hr	Approx. Film "Thickness" $\left(\frac{D}{k_L}\right)$ cm
			Stirred Water		
1	O_2	25	0.41	0.094	0.23
5	O_2	25	7.64	0.094	0.012
6	air	20	0.4	0.094	0.2
7	CO_2	25	1.46	0.074	0.051
12	CO_2	25	8.35	0.074	0.0089
			Gas Bubbles in Water		
16	O_2	20–21	88	0.094	0.0011
21	air	20–22	120	0.094	0.00078
			Water Drops		
22	CO_2	24	260	0.074	0.00028

creasing the pressure that is practical for water plants at present is air compression. The use of pure oxygen has been studied in connection with the activated sludge method of sewage treatment (*39*).

For gas release, the saturation value (S) obviously has to be kept as low as is reasonably possible. This objective can be accomplished by maintaining the minimum practicable partial pressure in the air surrounding the water. Consequently, for gas release, thorough ventilation of the structures enclosing aerators is essential. The work of Brown (*40*) at Memphis, Tenn., confirms this statement. His conclusion, based on pilot and full-scale (30-mgd aerator) observations, was that media in a tray type aerator should be so arranged that fresh air continuously passes over the water. It was further concluded that it is impossible to secure consistent results with an aerator dependent on natural ventilation alone. Fairly uniform results will be obtained if the aerator is not housed and if ventilation is not obstructed by other buildings (*40*). Ventilation is also of importance from a safety standpoint when carbon dioxide, methane, or hydrogen sulfide is being removed. The first is an asphyxiant, the second creates an explosion hazard, and the third is highly poisonous.

Theory leads to the prediction that aeration under pressure in a closed tank should be quite efficient as a means of adding oxygen to water but inefficient for carbon dioxide removal, even though the CO_2 removed and the excess air are periodically vented to the atmosphere. Under such aeration conditions, the oxygen partial pressure would be high and its absorption would be favored. The partial pressure of carbon dioxide in the gas pocket of the tank, however, would increase as removal continued, thus slowing the rate of release (*11*).

Practice often requires both oxygen absorption and carbon dioxide release in the same aerator, thus necessitating diffusion in both directions through the gas and water films. Where this requirement is to be met, theory indicates that adequate ventilation should be provided. This not only prevents the lowering of the oxygen partial pressure and the increasing of the carbon dioxide partial pressure, but offers the added advantage of air turbulence.

Forced-draft waterfall aerators often employ the countercurrent flow principle, particularly for carbon dioxide removal (*11*). Air is supplied at the bottom of the aerator enclosure and flows upward against the downward flow of the water. From a theoretical standpoint, an aerator of this type should be quite efficient for both oxygen absorption and carbon dioxide removal. Such an aerator will provide a continuous supply of new air, as well as thorough gas and water mixing and contact.

For gas release, reduction in partial pressure can be obtained by reducing the total air pressure or by the addition of inert gases, or both. Vacuum deaerators for boiler feedwater utilize the principle of reducing the dissolved air through the combined effects of lowered air pressure and high temperatures on gas solubility. Installations of large, cold-water, deaerating systems based solely on pressure reduction have been described by Powell and Bacon (*12*) and by Speller (*41*). Ippen (*32*) mentions nitrogen "stripping," a method in which nitrogen is bubbled through partially deaerated water to reduce dissolved oxygen to low levels.

Depth of Basin

Ippen (*32*) recognized the influence of water depth on injection aeration systems and made allowances for water pressure effects in computing gas transfer coefficients for experimental aerators of this type. Injection aerators normally are operated in basins of appreciable depth. Under such conditions, S and C_i are identical only at the surface. Changes in depth and resulting changes in pressure also affect the volume of a rising bubble and, consequently, the value of $\frac{A}{V}$. A rigorous mathematical description of gas exchange for a rising air bubble would be quite difficult to formulate.

Hydrogen Sulfide Removal Theory

Hydrogen sulfide removal presents a special aeration problem which is of considerable theoretical and practical interest. Hydrogen sulfide, a fairly soluble gas, is objectionable in water supplies because of its unpleasant odor at very low concentrations, its corrosiveness, and its high chlorine demand (*11, 42*). It can be removed by aeration, but several complicating factors exist. One of the most important properties of hydrogen sulfide is its high solubility in relation to that of carbon dioxide—approximately 3:1 (11). When water is aerated, the carbon dioxide comes out much more rapidly than the hydrogen sulfide, thus raising the pH of the water and shifting the H_2S ionization equilibrium toward the formation of more sulfide (HS^- and S^{--}), which cannot be removed by aeration. Another complication is the fact that aeration introduces oxygen, which reacts with the hydrogen sulfide to form water and free sulfur. The latter reaction reduces the sulfide content, but, unless the sulfur is removed, it may create further serious problems in connection with chlorination and water distribution (*42, 43*). Problems associated with sulfur bacteria following aeration have been described by Derby (*43*).

The efficiency of hydrogen sulfide removal by aeration, that is, its actual transfer from the water to the air, can be increased by aeration of the water in an atmosphere containing a high partial pressure of carbon dioxide. Such an atmosphere, which can be furnished by waste flue gases or by recarbonation equipment, will contain carbon dioxide on the order of 10 per cent, compared with approximately 0.03 per cent in ordinary air. This relatively very large concentration or partial pressure causes the carbon dioxide content of the water to increase during aeration, thereby decreasing the pH and maintaining it at a low value. The latter condition favors the H_2S form of the sulfide and its transfer from the water is effectuated. The carbon dioxide added can be removed in a second aerator of conventional design. It should be pointed out, however, that every hydrogen sulfide removal problem has its own peculiarities. Although the principles cited are valid, each instance should be given experimental study prior to the installation of full-scale equipment (*15*).

Taste and Odor Removal

No adequate theory can be proposed to describe the physical removal by aeration of the majority of taste- and odor-producing compounds, because there is very little knowledge of the physical and chemical nature of the vast majority of these substances. From the theory that has been developed, certain basic principles may be

drawn, but, for any specific situation, trial is the only method of determining what results can actually be achieved.

From the previous discussion of the theory of gas transfer, it is evident that solubility is an important property of compounds that are to be removed or reduced in concentration by aeration. Another important characteristic of the substance is its vapor pressure—the pressure at which a liquid and its vapor are in equilibrium at a given temperature (*10*). The vapor pressure of all substances increases with increasing temperature, and the temperature corresponding to a vapor pressure of 1 atm is the true boiling point of the substance. Vapor pressure has not previously been stressed in this paper because the gases thus far considered all show very high values at extremely low temperatures. The boiling point of oxygen is − 183°C and that of carbon dioxide is − 78°C.

Some idea of the relative vapor pressure of a substance may be obtained from its boiling point. Materials with high boiling points have lower vapor pressures at a given temperature than those with low boiling points. For example, phenol, which has a fairly high boiling point, has an almost negligible vapor pressure at ordinary temperatures. The vapor pressure of phenol is so small that it would not be at all practical to attempt its removal by aeration. Within the usual water temperature range, 0°–30°C, compounds which boil at much more than 0°C probably cannot be removed by aeration unless their solubility is quite low (*11*). Chlorine, with a boiling point of approximately − 34°C cannot be removed readily because of its fairly high solubility and its tendency to form compounds with water or other substances in it.

If the solubility and boiling point of any particular compound are known, a rough estimate of the probable efficiency of aeration in removing it can be made. In general, such estimates will show that almost none of the known taste- and odor-producing compounds—hydrogen sulfide is an exception—can be effectively removed by ordinary aeration processes. (The alleviation of tastes and odors through chemical changes resulting from the oxidation of these compounds by dissolved oxygen added by aeration is not pertinent to this discussion.)

Theoretical Aspects of Aeration Practice

In discussing aerator performance, Langelier (*23*) has called attention to the reciprocal relationship between contact surface and time. This relationship will be evident from an inspection of either Eq 8 or 10. For a given situation, as long as the product of $\frac{A}{V}$ and t remains constant, the performance will be the same. Therefore, other factors being equal, t may be increased at the expense of $\frac{A}{V}$ without loss of efficiency, and vice versa. For example, the effective exposure, $\frac{At}{V}$, of water stored in an open basin 10 ft deep for 0.5 hr will be equivalent to the effective exposure, $\frac{At}{V}$, of 1-cm diameter drops falling a distance of 15 ft. Allowance must be made, however, for the greater turbulence (and, hence, the thinner films and lack of concentration gradients) in the falling drops, a factor in their favor. Nevertheless, it must be concluded that, in the passage of water through a typical water

plant, considerable gas exchange will probably be obtained (*23*).

The reciprocal relationship between time and area exposed finds application in various types of aerators. In the waterfall type, the maximum surface area can be obtained by drop-producing spray nozzles, but the time of exposure will be short unless there is considerable expenditure of head to force the water high into the air. On the other hand, tray and cascade aerators generally produce less surface area, but the exposure period may be greater, because more time is required for water to fall through a series of trays or over cascades with alternate starting and stopping than to fall freely through the same vertical distance. As an example (based on falling-body formulas, with air friction neglected), the ratio of the aeration time provided by an aerator containing N equally spaced trays to that provided by a jet of water rising and falling the same distance is $\frac{1}{2}\sqrt{N}:1$. Thus, for a four-tray aerator, the theoretical aeration time would be the same as for a jet, but the aeration time would be greater for any larger number of trays. As in previous examples, factors other than time come into play, so that a comparison cannot be made strictly on that basis.

One factor, probably of some importance, that favors a tray or cascade aerator is the apparent rapid rate of gas transfer in newly formed drops and water layers. Conditions are favorable for the repeated destruction of old surfaces and the formation of new ones in a tray or cascade aerator.

Effective-Exposure Ratios

Water works installation statistics (*44*) show that the waterfall type of aerator is more commonly used than the injection type. The former has many practical, as well as certain theoretical, advantages. In theory, the waterfall type, particularly when employing sprays or jets, will break the water into turbulent thin layers and drops, which will have a high gas transfer coefficient (thin films) and a large surface-to-volume ratio. The principal theoretical disadvantage is the relatively short time of exposure that can be provided. The water in a jet rising 10 ft and then falling the same distance travels at an average rate of approximately 13 fps and, hence, has only about a 2-sec exposure to the air. On the other hand, a bubble of air of the size often employed in injection aerators has very little acceleration and a terminal velocity of the order of 1 fps (*32, 45*). Thus, a bubble rising through a water depth of 10 ft has a contact time of approximately 10 sec, or about five times that of the rising and falling drop. For an approximately equal expenditure of energy, a substantially longer contact period can be obtained in injection aerators than in the waterfall type.

To cite an example from Langelier (*23*), assume that a volume of water is aerated with an equal volume of air (measured under a pressure equal to water depth H), subdivided into bubbles of radius r in a basin of depth H; assume that another equal volume of water is subdivided into drops of the same radius (r) and allowed to drop through the same height (H). The energy requirements of the two methods are approximately the same. The effective exposure for the drops $\left(\frac{At}{V}\right) = \frac{3}{r}\sqrt{\frac{2H}{g}}$, while that for the bubbles is $\frac{3H}{\mu r}$, the rising velocity of the bubbles being μ fps. The ratio of the

effective-exposure factor of the bubbles to that of the drops is $\frac{1}{\mu}\sqrt{\frac{gH}{2}}:1$. (The constant, g, is the acceleration due to gravity, 32.2 fps per second.) If μ is 1 fps, then the ratio becomes $\sqrt{\frac{gH}{2}}:1$. Based on these assumptions, an air injection basin 16 ft deep would have an effective exposure approximately sixteen times as great as a waterfall aerator providing 16 ft of free fall. There appears to be a theoretical advantage in favor of the air injection aerator, despite the greater resistance to gas transfer resulting from thicker films. On the other hand, the time of exposure for the drops could be doubled, without additional energy expenditure, by the use of a nozzle which would jet the water 16 ft into the air initially. The effective exposure ratio favoring the injection aerator would thereby be halved, becoming 8:1.

A factor of some importance in the efficiency of bubble aerators is the pattern of flow of the water in the aeration basin, as induced by the bubbles themselves. A spiral flow pattern is desirable for two reasons: high water surface velocities, which promote gas transfer, are created; and a substantial number of bubbles do not escape to the atmosphere immediately but are carried across the aeration basin and held in a more or less fixed position by the descending water. In this position, the buoyancy of the bubble is just balanced by the drag of the descending water. Consequently, spiral-flow aerators are more efficient than the older ridge-and-furrow style.

Air Bubble Formation

The efficiency of injection aerators depends to a great extent on the size of the bubbles of air formed by the air injection equipment. The size used will be a compromise between the increased efficiency associated with small bubbles and the practical problems of maintaining equipment to produce them. In this connection, certain theoretical considerations and experimental data are of interest.

For orifice air injectors, the production of bubbles is related to both orifice diameter and rate of gas flow (*32*). Single bubbles are produced at low gas flow rates, their diameters being a function of the diameter of the orifice alone.

The size of a single bubble formed at low air flow rates by a simple injection device, such as a submerged pipe containing multiple air outlet orifices, is the resultant of a balance between two forces: the buoyant force of the bubble, which tends to separate it from the orifice, and the shear force necessary to break the surface tension across the orifice. The bubble must grow to a certain size in relation to the orifice before it can break away. Maier (*45*) found the relationship between the static bubble radius and the orifice radius to be approximately 10:1 for water and solutions of similar surface tension. Using a capillary tube orifice with a bore diameter of 0.1148 mm, Ippen (*32*) reported that, up to a critical gas flow rate of approximately 72 ml per minute, the bubbles emerged in single formation, with a constant diameter of 1.28 mm, approximately eleven times the orifice diameter. When the rate rose beyond this critical point, the bubble diameter increased with increasing gas flow and the bubbles emerged in chain formation. From this and other information (*46*), it appears that very small bubbles cannot be produced without the use of orifices of extremely small di-

ameter—so small, in fact, that they probably would not be practical because of rapid clogging. Work conducted by Beck (*46*) on porous diffuser plates confirmed the observation that the advantage gained by producing small bubbles through the use of devices of low permeability probably is not worth the extra burden of maintenance which such devices impose.

The fact that the diameter of the bubbles formed will be of the order of

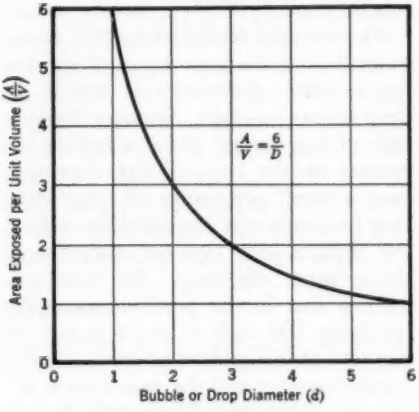

Fig. 6. Bubble Diameter and Area-Volume Ratio

The area exposed per unit volume of spherical drops or bubbles has an inverse relationship to the diameter.

at least ten times the orifice diameter suggests a minimum spacing of at least ten orifice diameters between orifices, in order to minimize the chance for coalescence of the bubbles after they have been formed (*45*).

Much of the work conducted by Maier (*45*) on bubble formation was aimed at the production of small bubbles, using fairly large air injection orifices. He reported successful results, on a laboratory scale, employing various devices to produce a shearing stress on the bubble sufficient to cause it, while still small, to break away from the orifice. Langelier (*23*) also carried out work on devices using this principle. If properly applied, this method would have the obvious advantage of producing small bubbles while releasing air through fairly large orifices not subject to the clogging problems associated with small ones.

Bubble Velocity

Information presented by Ippen (*32*) indicates that the terminal velocity reaches a maximum for single bubbles with a diameter of approximately 1.2 mm. This maximum velocity is approximately 32 cm per second (1.05 fps). For slightly larger bubbles, the velocity of rise decreases a little, to a minimum value of approximately 25 cm per second (0.8 fps) for a 6-mm bubble diameter. A further increase in diameter results in greater velocity, a bubble of 20-mm diameter having a rising velocity approximately equal to that of a 1.2-mm bubble (about 1 fps).

The air and water used in the preceding experiments (*32*) were filtered. Haberman and Morton (*47*) have reported increased drag (lowering of the terminal velocity) for bubbles with diameters in the range 0.6–5 mm, when dispersed in water containing small amounts of suspended matter. The terminal-velocity decrease may be of the order of 50 per cent for 1.4-mm bubbles. These investigators believe that minute amounts of suspended matter produce effects at the bubble film which cause a lowering of the terminal velocity. Similar effects would probably be noted in raw waters. The same investigators also reported that the presence of surface-active substances in the water increased bubble drag. One substance that produced

this effect was a nonionic liquid detergent.

Porous air diffuser plates of the permeability most commonly used produce bubbles 25–30 mm in diameter (*21*).

Drop and Bubble Surface Areas

The factor $\frac{A}{V}$, representing the surface contact area available for gas transfer per unit of volume, is of importance in aeration efficiency. The rate of gas transfer is directly proportional to this factor (Eq 8 and 10). Consideration of the relationship between the surface area and the volume of a sphere is, therefore, of some interest in any theoretical discussion of aeration. If air bubbles rising through water and drops falling through air are assumed to be nearly spherical in shape, the principles discussed apply to some extent to both types of aeration devices.

The area (A) of a sphere of d diameter is πd^2; its volume (V) is $\frac{\pi d^3}{6}$. Then:

$$\frac{A}{V} = \frac{\pi d^2}{\frac{\pi d^3}{6}} = \frac{6}{d}$$

Figure 6 indicates this relationship graphically. When d is small, $\frac{A}{V}$ is large, and conversely. Inasmuch as, for any fixed conditions of concentration difference ($C_t - S$; or $S - C_t$) and gas transfer coefficient (k), the rate of gas transfer is proportional to $\frac{A}{V}$, the efficiency of aeration will decline with increasing drop diameter in approximately the same way as the $\frac{A}{V}$ factor shown in Fig. 6 declines.

Some idea of the enormous area involved when small bubbles or drops are produced may be obtained by considering 100 cu ft of air or water. This volume of either, if in the form of a single sphere, would have a surface area of approximately 104 sq ft. When divided into drops or bubbles 0.1 in. in diameter, however, the surface area becomes approximately 72,000 sq ft, and the $\frac{A}{V}$ factor changes from 1.04 to 720 per foot. ($\frac{A}{V}$ has the dimensions $\frac{1}{\text{length}}$; in this instance, $\frac{1}{\text{foot}}$.)

Theoretical considerations (*45*) serve to emphasize the importance of obtaining as much uniformity in bubble or drop size as possible. Because the volume of a spherical drop or bubble increases as the cube of the diameter, even a small percentage of large bubbles or drops can considerably reduce the surface area exposed and, hence, the aeration efficiency. To illustrate, assume that in the previous example, involving 100 cu ft of air or water, 99 per cent of the bubbles or drops are 0.1 in. in diameter and the rest have a diameter of 0.5 in. There will be approximately 147,000,000 bubbles or drops, of which 1,470,000 will have a diameter of 0.5 in. and a combined volume of approximately 56 cu ft. The other 99 per cent, with a diameter of 0.1 in., will have a volume of only 44 cu ft. In other words, 1 per cent of the bubbles or drops will contain 56 per cent of the total volume. For the 0.5-in. bubbles or drops, the combined surface area will be approximately 800 sq ft. For the 0.1 inch bubbles or drops, the combined surface area will be approximately 32,000 sq ft. The total surface area and the $\frac{A}{V}$ factor will therefore be approximately 33,000 sq ft and 330 per foot, respectively, or less

than half that available when all the drops are 0.1 in. in diameter. Viewed another way, if only 1 per cent of the drops are five times oversize, the rate of gas transfer will be decreased by more than 50 per cent.

Acknowledgment

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Production and Use of Cast-Iron Pressure Pipe

BDSA Study

A study released for publication in March 1954 by the Water & Sewerage Industry & Utilities Div., Business & Defense Services Administration, US Dept. of Commerce, Washington, D.C.

AT intervals during the past several years, problems were presented to the department which required some study of the production and use of pipe in the field of water and sewerage works. During these studies data were collected and estimates prepared which were revised at some later periods in reconciliation with additional data obtained. More particularly, in the study of the production and use of cast-iron pressure pipe, it appeared that projections based upon those estimates proved to be reasonably in line with the total actual usage.

Manufacturers of that product, and others who were interested because the trends affected their field of activity, have requested that the data be assembled and released for such benefit as it may afford to their own marketing studies. In response to their requests, the Water and Sewerage Industries and Utilities Div. of the Business and Defense Services Administration, US Dept. of Commerce, presents this condensation of studies on cast-iron pressure pipe.

Using available statistics and interpolations where necessary, Fig. 1 shows the growth of our national population and the estimated community population. This estimated community population includes only the portions of the rural nonfarm population which are grouped in sufficient number or close enough to an urban area to be considered eligible for public water service. The estimated total population served by public water systems is shown to have more than doubled since 1910, and the total average daily water use is shown to have more than tripled in that same period of time.

The general trend of increase in percentage of total US population grouped in communities, the increase in percentage of community population served by public water systems, and the increase in per capita water use are all indications of the need for accelerated provision of extensions of water service and of additional supply for their requirements. These trends can be interpreted as indicating a need for an increased volume of construction in the water and sewerage works field in the years ahead.

The principal available statistics on cast-iron pressure pipe are found in publications of the American Iron and Steel Institute, from 1915 to 1938; the Cast Iron Pressure Pipe Institute, from 1939 to 1942; and the Bureau of the Census publications from 1943 to 1952. The reports vary, some publications covering production and others shipments. In some years fittings were included, and in others excluded. During some periods of time the records include culvert pipe. An attempt was made to readjust all of these to show

at least representative annual production of cast-iron pressure pipe and fittings.

During the years 1950–52 the Bureau of the Census reported a breakdown of three size groups for cast-iron pressure pipe: under 14 in., 14–24 in., and over 24 in. Using this pattern and the Cast Iron Pressure Pipe Institute's soil pipe. From this, using knowledge of occurrences in certain years, the division has estimated the cast-iron pressure pipe and fittings imported annually.

The total of our national production and the imports represent the cast-iron pressure pipe available for distribution. For further analyses, the presentation

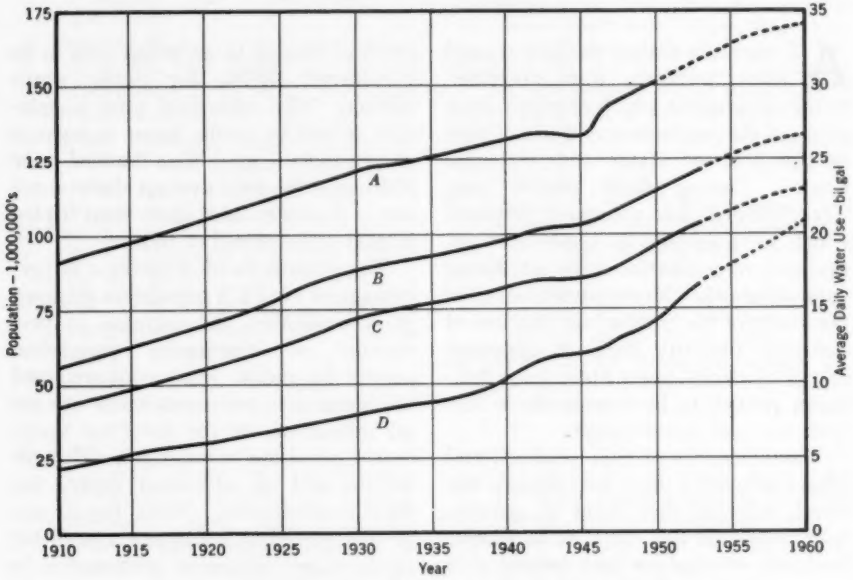

Fig. 1. Population and Water Supply Growth Trends

Key: A—*total US population;* B—*estimated total community population;* C—*estimated total population served by public water systems;* D—*average daily water use.*

figures on total production from 1921 to 1947 as guides, the division has estimated the breakdown for each year (Fig. 2).

Available statistics on imports, as published by the Bureau of the Census in "Foreign Commerce and Navigation of the United States," include cast-iron pressure pipe, screwed pipe, and is confined to what may be termed the distribution sizes from 2 to 12 in. in diameter. The sizes for mains (14–24 in.) and for supply lines (over 24 in.) are affected by different factors, which produce an increase in demand lagging behind that for the distribution sizes.

In the comparison of the annual production as shown in Fig. 2, attention

must be called to the fact that these annual tonnages, particularly of the sizes from 2 to 12 in., do not represent comparative footages, due to the gradual change from pit-cast pipe in the early 1920's to largely centrifugal pipe, lighter in weight per foot, since 1940. For instance, the large tonnage of production in 1926 does not represent as much footage as the production of 1951.

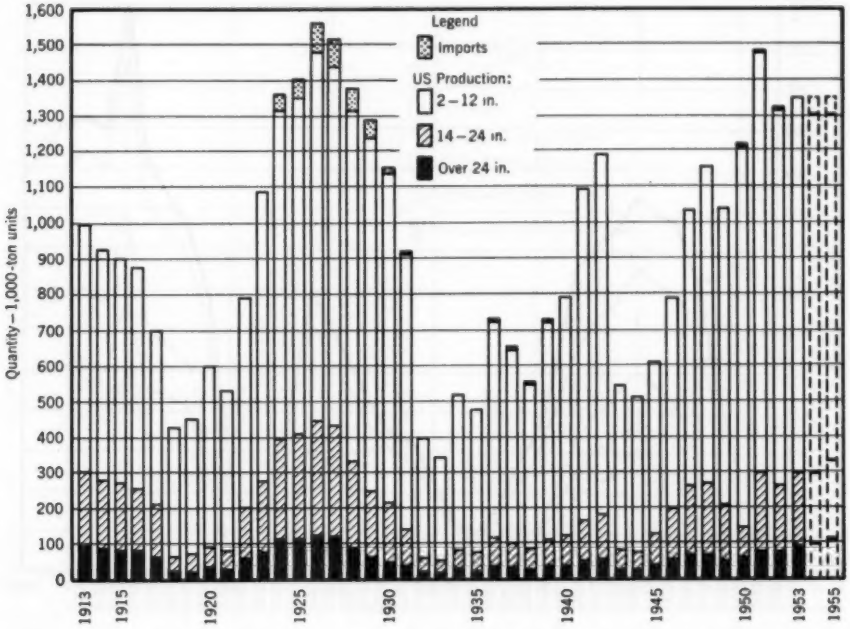

Fig. 2. Estimated US Production and Imports of Cast-Iron Pressure Pipe and Fittings

Owing to changes in the type of casting preferred, the relation between tonnage and footage has varied over the years.

One of the important factors in the demand for distribution sizes is the annual volume of new nonfarm housing units. Figure 3 breaks down the nonfarm housing program in order to show its effect upon the construction of water distribution extensions. Duplexes, row houses, and multifamily buildings are so condensed that their requirements in tons of pipe are much less than the requirements per unit in a completely detached single-family development. The "equivalent one-family houses in cast-iron pressure pipe requirements" represents the reduction of the total program into an equivalent number with respect to distribution pipe requirements.

Due to economic factors, a varying proportion of the annual housing program is constructed on developed lots

already served by water mains, and the remainder is placed on undeveloped land, requiring the construction of new water distribution lines. The chart shows the "equivalent number of housing on undeveloped land" for which water distribution would be desirable. However, some of these are too far distant for economical provision of immediate water service and must be served by wells or other means. The chart shows the "equivalent number receiving water service."

In translating the trends in Fig. 3 for use in Fig. 4, it was necessary to take into account the gradual change in technology of water works practice from the use of smaller sizes, especially 4 and 6 in., to the more frequent use of 8 and 12 in. and the looping-in of dead ends, to provide both better service and more adequate fire protection. From 1924 to 1930 use was affected by heavy imports of foreign centrifugally cast pipe, and the trend of American manufacture changed from pit-cast pipe in the 1920's to almost entirely centrifugal pipe production in the early 1940's. The use pattern was changed from approximately 90 per cent cast-

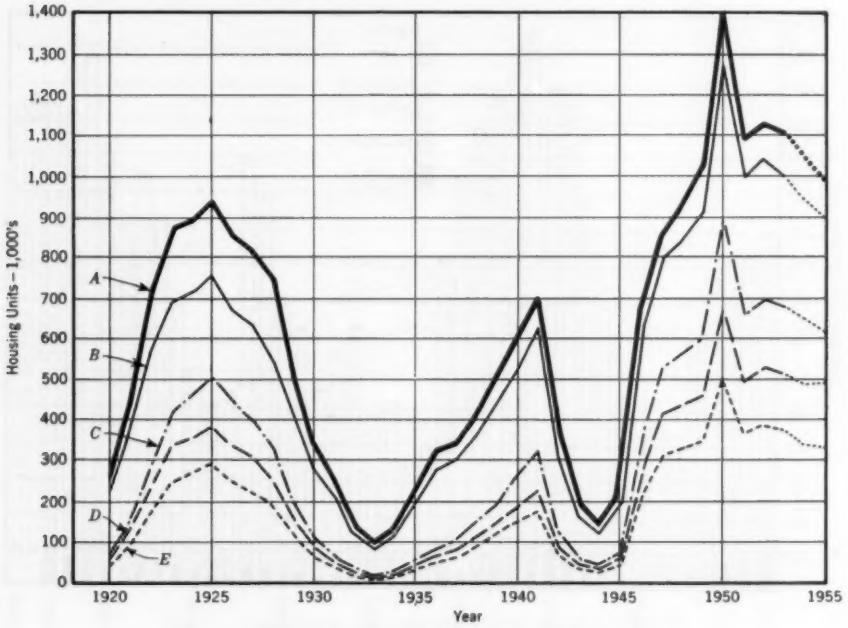

Fig. 3. Water and Sewer Service for New Housing

Key: A—*total number of family units;* B—*equivalent one-family houses in cast-iron pipe requirements;* C—*equivalent number of houses on undeveloped land;* D—*equivalent number receiving public water service;* E—*equivalent number receiving public sewer service.*

iron pressure pipe in the early 1920's to the present postwar pattern in which other types of pipe are providing about 25 per cent of the distribution systems' requirements. These include pipe of steel, asbestos-cement, and reinforced concrete.

In Fig. 4, uses have been divided into five principal categories; water and sewerage works include three of these—maintenance and replacement, distribution system extensions to new homes, and general construction. Each of these may be more explicitly defined as follows: "Maintenance and replacement" includes not only the standard utility definition of maintenance but also the replacing of an old main with a new one for any reason. "Extensions to new homes" includes extensions only to that year's new housing program. "General construction" includes any general system or plant improvements, extensions of distribution systems to old homes of previous years' construction, and the construction of complete new water works systems.

Other uses include maintenance and replacement and new construction of manufacturing industrial plants, military facilities, and gas distribution. Exports include shipments to Canada,

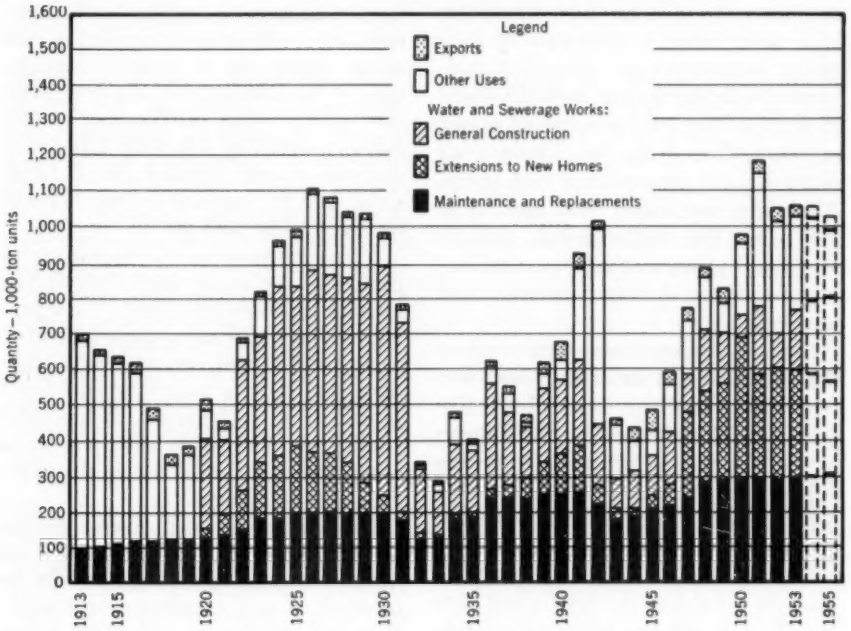

Fig. 4. Distribution of 2–12-in. Cast-Iron Pressure Pipe

The categories given in the legend are defined in the text.

but do not include shipments to United States territories and possessions. Shipments to the Philippines are included as exports since they have been granted their independence.

In estimating the use of cast-iron pressure pipe for water and sewerage works construction, the Dept. of Commerce estimated volume of new construction put in place has been used as a base. To this, varying percentages have been added to take care of estimated undercoverage, and then converted to the equivalent annual volume in terms of the 1950 purchasing power of the dollar, using the *Engineering News-Record* construction cost index. A varying use factor was applied in line with the technological changes mentioned above and other special factors occurring during depression and war years.

Similar developments were made of the estimated use for maintenance and replacement and for other uses. Export data as published by the Bureau of the Census and other sources were adjusted to estimated quantities covering only cast-iron pressure pipe and fittings.

Slight revisions were necessary to readjust the estimated distribution each year in line with the estimated production. The charts were completed before full statistics were available for 1953, so that a slight revision may yet be necessary for that year.

Summary

Using the past years as a guide, and with the benefit of several predictions by economic groups and experts for 1954 and later years, it is possible to project a pattern for 1954 and 1955. This reflects an increase in water and sewerage works construction, although a probable slight decrease in number of new housing units serviced. It reflects a decrease in military and manufacturing industrial construction for water supply, but a probable continuance of the demand for cast-iron pressure pipe for gas distribution. Comparisons with Fig. 2 indicate a probable decrease in the demand for 2–12-in. sizes, but an increase in the demand for sizes 14 in. and up.

These charts present a representative picture of the years since 1940 and at least an approximate picture of the preceding years. By using these and other pertinent data and varying the assumptions and factors according to known practices, it is believed that similar studies could be made with respect to other water and sewerage works materials and equipment.

In coordinating the several studies and estimates, the division realizes the deficiencies and accordingly will be interested in any comments or suggestions for revision, in order that future studies may best serve their purposes, and, more especially, so that they may be of greatest benefit to the water and sewerage area of business and industry.

Decreasing Costs by Improved Handling of Materials

By O. S. Carliss

A paper presented on Oct. 22, 1953, at the New Jersey Section Meeting, Atlantic City, N.J., by O. S. Carliss, Director of Eng., Yale & Towne Mfg. Co., Philadelphia.

THE tremendous demands of World War II dramatized the necessity for mechanized handling and demonstrated the practicality of replacing muscles with motors. Largely because of the perpetual mountain of goods and materials that had to be moved for the armed forces, new types of equipment, new attachments, and new procedures were developed. The impetus toward improvements in material handling has continued into the postwar era. Only recently, however, have the operators of water supply facilities taken a major interest in this subject.

The amount of material added to water during the course of treatment is relatively small. In the past men needed at the plant for other duties could empty the necessary bags of chemicals into the feeders with very little expenditure of time. It has now become necessary, however, for operators to review the situation. Housing and population growth has greatly increased the amount of water being used. To meet this demand, the output of existing facilities must be enlarged and new plants constructed. Operating expenses have risen sharply, and labor is in short supply. Improved methods of handling materials constitute an increasingly important means of cutting material costs.

Through the use of fork trucks (Fig. 1), which are adapted to high stacking of palletized loads, the amount of floor area allocated to the storage of bags of dry chemicals can be materially reduced. Palletized loads can be readily stacked three tiers high. This provides the same reserve supply in one-third the space and affords a considerable saving in building costs. When planning a new facility or modernizing an existing plant, the designer should take into account the many operational advantages that mobile, power-operated equipment provides in elevating, moving, and storing, not only dry chemicals, but also other types of supplies—including pipe (Fig. 2), fittings, and meters.

The producers of dry chemicals have pioneered many of the advances in handling methods. They have led the way in developing palletized loads and unit loading. Their plants, warehouses, and shipping facilities are developed around the modern fork truck. Most suppliers prefer to load trailers and boxcars with palletized loads. If they are required to hand-load a car, their labor cost goes up. Although, in view of the comparatively small amounts of dry chemicals used daily at the water plant, some planning would be required to arrange for palletized-

Fig. 1. Fork Truck

This 2,000-lb capacity, gasoline-powered truck can stack pallet loads three tiers high.

load shipments and to store the larger quantities of materials this method would entail, such an effort would lead to easier handling and, hence, to lower cost.

Mechanized handling increases labor efficiency. Since the advent of automatic and remote controls and the use of electrically driven pumps, the manpower requirements at water plants have steadily lessened. When mechanized equipment is used, existing personnel can readily handle the incoming shipments of dry chemicals and the delivery of chemicals to the feeders.

An analysis of accident records indicates the need to eliminate manhandling of bulky, heavy materials. A fork truck can handle 2,000 lb or more of material with ease. It can pile this material 10–12 ft high in safety or deliver it to elevated feeders on balconies or raised platforms. As the truck requires no more effort to operate than an automobile, it can be used by older employees who could not, and should not be allowed to, handle heavy objects.

A survey of operations to improve material handling consists of three steps: [1] determining how each important handling job should be done; [2] deciding what equipment is essential to do it; and [3] planning the in-

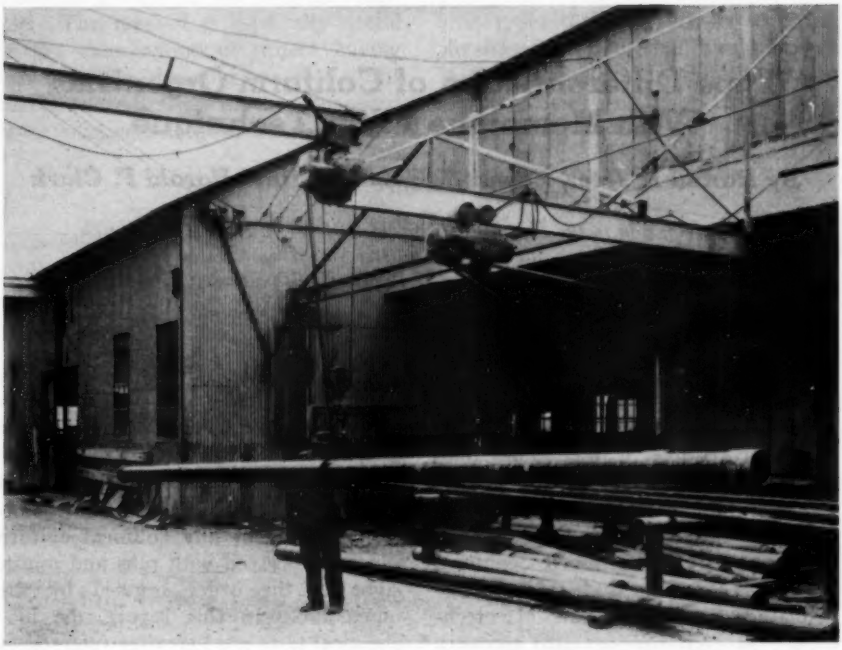

Fig. 2. Hoisting Pipe

Electric hoists can handle long sections of heavy pipe efficiently and safely.

tegration of this equipment into an overall system for operation at maximum capacity.

When a mechanized handling system is in operation in any plant where production and material handling are integrated, there will always be a great saving in movement, an improvement in the ratio between productive and nonproductive workers, and a flexibility in production that can help to absorb volume fluctuations.

Modern material-handling equipment is important, not only to management, but to workers, stockholders, and customers as well.

Type Differentiation of Coliform Organisms With Membrane Filter Technique

By Harold L. Jeter, Edwin E. Geldreich, and Harold F. Clark

A contribution to the Journal by Harold L. Jeter, Edwin E. Geldreich, and Harold F. Clark, all Bacteriologists, San. Eng. Center (formerly Environmental Health Center), US Public Health Service, Cincinnati, Ohio.

IN a recent field study of water examination by the membrane filter (MF) and *Standard Methods* (*1*) MPN procedures, it was found that, for approximately 75 per cent of the samples, the MF results fell within the 95 per cent confidence limits of the simultaneously determined coliform MPN (*2*). In this study, using modified Endo media with the MF technique, the coliform-organism recovery showed a trend toward lower estimates with the MF procedure than with the MPN. Whether this trend was due to the inability of some coliform organisms to produce differentiated (sheen) colonies on the MF cultures or to other causes is a pertinent consideration.

France (*3*) and Ruchhoft and colleagues (*4*) have differentiated types of coliform organisms in water samples by determining the biochemical reactions (indole, methyl red, Voges-Proskauer, citrate, and others) of pure cultures recovered from differential solid media. A statement of British practice in the biochemical differentiation of the coliform group into named types is reproduced in *Standard Methods* (*1*, p. 238), together with designations of probable habitats and a discussion of the relative sanitary significance of these named types. Parr (*5*) introduced into the United States the mnemonic "IMViC" to designate these reactions: *I* represents the indole test, *M* the methyl red, *V* the Voges-Proskauer, and *C* the citrate test (*i* is inserted for euphony). The biochemical reactions of any coliform culture can be expressed with plus and minus signs in the order implied by the mnemonic. In this report, the biochemical tests are hereafter referred to as the "IMViC tests." A classification of the coliform group based on these tests is given in *Standard Methods* (*1*, p. 229).

Direct plating methods on agar media, applied to waters having low coliform densities, necessitate a considerable amount of platings in order to secure a representative number of cultures for further study. Attempts to overcome this difficulty through preliminary enrichment of the samples in fluid media prior to isolation of pure cultures frequently permit predominant or exclusive growth of one or a few strains at the expense of other organisms present.

Membrane filter procedures offer an excellent primary plating technique for demonstrating quantitatively the distribution of bacterial species (and, more specifically, of subgroups within the

coliform group) in the original sample. The method is especially useful in the examination of waters having low coliform densities, as it permits direct concentration of the organisms from relatively large sample volumes. Separate colonies develop on the filter surface; from these, pure cultures may be recovered and subjected to further biochemical tests. Vigorous colony growth of one or more types of coliform organisms does not suppress growth of other, less numerous, coliform types that may not be so active physiologically and that would be less likely to be detected by different methods of primary isolation. In this way, type differentiations approximating their relative numerical distribution in the sample source are obtained.

In this study, the coliform content of water samples was determined simultaneously by the MF technique, using Environmental Health Center (EHC)

TABLE 1

Colony Types on Membrane Filters

Colony Type	MF Medium	Metallic Yellowish Surface Luster	Colony Center	Periphery	Remarks
			Coliform Type		
A	EHC	yes	deep red	deep red to colorless	colonies convex, usually with smooth surface; sometimes deeply convoluted
	BGF	yes	deep blue-purple	blue-purple to colorless	
			Other Types		
B	EHC	no	pink	light pink to colorless	colonies convex, with smooth surface
	BGF	no	purple	light purple to colorless	
C	EHC	no	pink	ligh pink to colorless	colony surface uneven, sometimes granular; flattened
	BGF	no	purple	light purple to colorless	
D	EHC	no	deep red	deep red	small colonies, less than 1 mm in diameter; smooth; convex
	BGF	no	blue-purple	blue-purple	
E	EHC	no	colorless	colorless	colonies usually quite small; smooth; convex
	BGF	no	colorless	colorless	

Endo and brilliant green–fuchsin (BGF) media, and the *Standard Methods* "confirmed-test" and "completed-test" MPN procedures. The samples were chosen from sources known to contain several intermediate coliform types, as well as typical *Esch. coli* and *Aer. aerogenes* strains. To show the distribution of coliform types in the samples and the correlation between sheen production on membrane filters and gas production from lactose fermentation tubes, determinations of the IMViC reactions and of the ability to ferment lactose with gas production were made on purified cultures derived from sheen-producing and nonsheen-producing colonies.

Method

With the objective of securing a broad range of coliform types in terms of the IMViC classification, samples were collected from six sources: a major river; the primary settling basin of a water treatment plant; a creek, ½ mile below a sewer outfall; domestic sewage; a lagoon; and a farm well. All of these samples were taken during the summer months to avoid the possibility that seasonal fluctuations in the bacterial flora of natural waters might affect MF colony specificity.

Bacteriological examinations were initiated within 2 hr after sample collection. Although this study was not primarily concerned with the analysis of quantitative coliform productivity by the MF method, simultaneous examinations were made by both the MPN and the MF methods.

Previously described methods (*2*) were used in the MF tests. Briefly, the methods consisted of sample filtration, 2-hr incubation at 35°C on enrichment medium, transfer to differential coliform media, and further incubation for 16–18 hr at 35°C. Colony counts were made at 15× magnification with vertical illumination. Both EHC Endo medium and BGF medium were used as differential coliform media in these studies.

Five-tube MPN estimations of coliform density were made, using the procedures recommended in *Standard Methods* (*1*). Confirmed-test and completed-test estimates of coliform density were made for all samples.

Following the counting of MF coliform type colonies, representative, well isolated colonies were selected for further study and were classified according to the characteristics given in Table 1. Transfers were made to fermentation tubes containing BGB 2 per cent.* The cultures were incubated at 35°C and examined at 24 and 48 hr for evidence of gas formation. Cultures not producing gas within 48 hr were recorded as noncoliforms and discarded. Cultures producing gas within 48 hr were reisolated by streak inoculation on EMB agar. After 24-hr incubation, well isolated colonies were picked from the EMB agar and transferred to nutrient-agar slants, which were, in turn, incubated for 24 hr at 35°C. These nutrient-agar slant cultures were used as the source of inoculum for the following media: lactose broth, tryptone broth,* methyl red–Voges-Proskauer medium,* and Simmons citrate medium.*

The lactose broth cultures were incubated at 35°C and were examined at 24 and 48 hr for gas production, as a check on the possibility of personal error in making transfers from EMB agar to the nutrient-agar slants. The

* Products of Difco Labs., Inc., Detroit, were used.

IMViC tests were performed according to the procedures recommended in *Standard Methods (1)*.

A limited number of cultures giving IMViC results that appeared questionable were subjected to repeated IMViC study. Such cultures were reisolated on EMB agar, and triplicate subcultures were reexamined by the IMViC methods outlined above.

Results and Discussion

Quantitative studies. The MPN and MF estimates of coliform density shown in Table 2, though not representing a sufficient number of samples for detailed analysis, are illustrative of the type of results commonly encountered in comparisons of the two methods. Five of 6 MF results on EHC Endo medium and 4 of 5 results on BGF medium are lower than the confirmed-test estimate of coliform density. Using the 95 per cent confidence limits (0.3 and 2.9 times the calculated MPN) as the standard of agreement between the two methods, 5 of 6 results on EHC Endo medium and all on BGF medium coincide with the MPN estimates of coliform density.

Five of 6 MF tests on EHC Endo medium and 4 of 5 tests on BGF medium give results lower than the completed-test estimate of coliform density. Using the 95 per cent confidence limits as the standard of agreement between the two methods, all of the results from both MF media coincide with the MPN estimates of coliform density.

Comparisons between the two MF media show that the overall productivity of sheen-producing (coliform type) colonies on BGF medium is 92 per cent of that on EHC Endo medium.

TABLE 2

Coliform Density, MF Versus MPN Method

Sample*	MF Method		5-Tube MPN Method			
	EHC Endo	BGF Medium	Confirmed Test	95% Confidence Limits†	Completed Test	95% Confidence Limits†
	Coliform Organisms per 100 ml					
1	130,000	130,000	170,000	53,000–490,000	170,000	53,000–490, 00
2	27	25	79	23–230	79	23–230
3	320,000	280,000	350,000	110,000–1,000,000	350,000	110,000–1,000,000
4	130,000,000	110,000,000	270,000,000	84,000,000–780,000,000	170,000,000	53,000,000–490,000,000
5	9,200		49,000	15,000–140,000	22,000	6,800–64,000
6	660	680	240	74–690	240	74–690

* Sample sources: [1] river, [2] water treatment plant, [3] creek, [4] domestic sewage, [5] lagoon, [6] farm well.

† 95% confidence limits are 0.3 and 2.9 times calculated MPN.

Qualitative studies. The results of biochemical studies of MF colony differentiation (outlined in Table 1) are given in Table 3. These data show that most coliform organisms growing on the membrane filter develop a characteristic "metallic" yellowish surface luster and subsurface color. It is also apparent that most colonies not developing the sheen and color do not represent coliform organisms.

There is little difference in percentage verification of coliform type col-

TABLE 3

*Validity of Colony Differentiation on Membrane Filter**

Sample†	Colony Breakdown	EHC Endo Medium					BGF Medium				
		Colony Type									
		A	*B*	*C*	*D*	*E*	*A*	*B*	*C*	*D*	*E*
1	No. examined	55	33	2	21	4	75	29	0	12	4
	No. coliforms	45	1	1	0	0	66	5	0	0	0
	No. noncoliforms	10	32	1	21	4	9	24	0	12	4
2	No. examined	15	56	1	0	43	21	65	0	0	38
	No. coliforms	14	3	1	0	0	21	1	0	0	0
	No. noncoliforms	1	53	0	0	43	0	64	0	0	38
3	No. examined	40	27	0	1	6	60	39	0	1	3
	No. coliforms	35	5	0	0	1	56	6	0	0	0
	No. noncoliforms	5	22	0	1	5	4	33	0	1	3
4	No. examined	95	32	0	0	0	69	36	0	1	4
	No. coliforms	92	1	0	0	0	66	6	0	1	1
	No. noncoliforms	3	31	0	0	0	3	30	0	0	3
5	No. examined	90	48	0	1	11					
	No. coliforms	80	1	0	0	0					
	No. noncoliforms	10	47	0	1	11					
6	No. examined	75	21	0	0	54	75	15	0	0	60
	No. coliforms	74	0	0	0	0	75	0	0	0	0
	No. noncoliforms	1	21	0	0	54	0	15	0	0	60
Total No. examined		370	217	3	23	118	300	184	0	14	109
Total No. coliforms		340	11	2	0	1	284	18	0	1	1
Per cent coliforms		92	5	67	0	1	95	10	0	7	1
Total No. noncoliforms		30	206	1	23	117	16	166	0	13	108
Per cent noncoliforms		8	95	33	100	99	5	90	0	93	99

	EHC Endo Medium	BGF Medium
Total No. examined, *B–E*	361	307
Total No. coliforms, *B–E*	14	20
Total noncoliforms, *B–E*	346	287
Per cent *B–E* colonies verified as noncoliforms	96	93
Total No. colonies examined	730	607
Total No. colonies verified	686	571
Per cent validity of colony differentiation	94	94

* Based on gas production from BGB 2 per cent.
† Sample sources as in Table 2.

onies (Type *A*) as between EHC Endo and BGF media. Of colonies of this type, 92 and 95 per cent, respectively, produce gas when transferred to lactose broth fermentation tubes. Likewise, there is little difference in percentage verification of noncoliform types of colonies (Types *B*, *C*, *D*, and

E) as between the two media. Of these types of colonies, 96 and 93 per cent, respectively, do not produce gas when transferred to lactose broth fermentation tubes.

Among the Type *A* colonies are some that produce no gas from lactose broth within 48 hr at 35°C but develop the typical color and surface sheen, a fact which results in their being enumerated as coliform colonies. The other types (*B, C, D,* and *E*) include some colonies that do produce gas within 48 hr when transferred to lactose broth and incubated at 35°C. These two sources of error tended, in this investigation, to cancel one another in coliform enumeration. Inherent differences in the composition of the bacterial flora from sample to sample preclude the derivation of arbitrary correction factors to compensate for these discrepancies.

Although 67 per cent of the Type *C* colonies from EHC Endo medium are demonstrated to represent coliform organisms, this type actually accounts for only 0.4 per cent of the total number of colonies subjected to verification study. Therefore, the likelihood that Type *C* colonies might materially affect the enumeration is small.

The results of biochemical studies of coliform organisms recovered from the samples are summarized in Table 4. In the following discussion, the IMViC formulas are in the order implied by the IMViC mnemonic. For example, a formula of + − − + designates a coliform culture shown through biochemical tests to be indole positive, methyl red negative, Voges-Proskauer positive, and citrate positive.

Both MF media differentiate as coliforms, through the development of colony surface sheen, a variety of

TABLE 4

Percentage Frequency of IMViC Categories (Coliform Colonies) on MF Media

Classification I M V C	EHC Endo Medium				BGF Medium			
	Type *A*		Types *B–E*		Type *A*		Types *B–E*	
	No.	%	No.	%	No.	%	No.	%
− − − −	0	0	0	0	0	0	0	0
− − − +	1	0.29	0	0	1	0.35	0	0
− − + −	2	0.59	0	0	2	0.70	0	0
− + − −	4	1.18	0	0	3	1.05	1	5.00
+ − − −	0	0	0	0	0	0	0	0
− − + +	124	36.47	11	78.57	99	34.86	11	55.00
− + + −	0	0	0	0	0	0	0	0
+ + − −	99	29.12	0	0	87	30.63	4	20.00
− + − +	40	11.76	2	14.29	31	10.92	1	5.00
+ − + −	0	0	0	0	0	0	0	0
+ − − +	0	0	0	0	0	0	0	0
− + + +	39	11.47	1	7.14	40	14.08	2	10.00
+ − + +	1	0.29	0	0	0	0	0	0
+ + − +	8	2.35	0	0	7	2.46	1	5.00
+ + + −	0	0	0	0	1	0.35	0	0
+ + + +	22	6.47	0	0	13	4.58	0	0
Total	340	99.99	14	100.00	284	99.99	20	100.00

TABLE 5

Percentage Frequency of IMViC Categories (Differential Coliform Colonies) on MF Media, Compared With Results of Other Investigations

IMVC	MF Media		Results of Other Investigations*										
	EHC Endo	BGF	Milk (6)	Human Feces (6)	Cow Feces (6)	Hides (6)	Dust (6)	Natural Waters (4)	Fresh Feces (7)	Refrig. Feces (7)	37°C Stored Feces (7)	Water (3)	Human Feces (3)
	Water	Water											
− − − −	0	0	0	0	0	0	0	0.72	0	0	0	0	0
− − − +	0.29	0.35	0	0	0	0	0	5.69	0	0	0	0	0
− − + −	0.59	0.70	2.28	0	0	0.19	0.14	0.33	0	0	0	1.8	0
− + − −	1.18	1.05	2.58	0.72	4.44	1.52	3.00	2.82	0	0	0	1.3	1.1
+ − − −	0	0	0	0	0	0	0	0.33	0	0	0	0	0
− − + +	36.47	34.86	50.81	14.03	0	49.62	46.57	18.11	16.51†	0	15.14†	6.7	2.7
− + + −	0	0	0	0	0	0	0	0.14	0	12.90†	0	0	0
+ + − −	29.12	30.63	13.92	78.42	95.56	35.42	30.00	34.54	75.79†	0.36	69.50†	60.5	93.2
− + − +	11.76	10.92	20.54	3.60	0	5.11	10.29	10.65	5.54	59.11†	6.52	8.5	1.1
+ − + −	0	0	0	0	0	0	0	0.24	0	7.99	0	0.4	0
+ − − +	0	0	0	‡	0	0	0	2.72	0	0	0	0	0
− + + +	11.47	14.08	‡	1.08	0	‡	‡	3.15	0	4.67	0.99	0	0
+ − + +	0.29	0	7.81	2.16	0	7.20	6.57	5.16	1.41	2.96	4.31	0.4	0
+ + − +	2.35	2.46	2.06	0	0	0.95	3.43	9.79	0.35	4.79	2.54	20.1	1.7
+ + + −	0	0.35	0	‡	0	0	0	0.14	0.05	0	0	0	0
+ + + +	6.47	4.58	‡		‡	‡	‡	5.45	0.35	7.22	0.99	0	0
Total %	99.99	99.99	100.00	100.01	100.00	100.01	100.00	99.98	100.00	100.00	99.99	99.7	99.8
No. of IMViC types	10	10	7	6	2	7	7	16	7	8	7	8	5
No. of cultures	340	284	1,358	278	383	528	700	2,093	1,987	1,690	905	223	178
Order of frequency	− − + + + + − − − + − + − + + + + + + +	− − + + + + − − − + + + − + − + + + + +	− − + + − + − + + + − − + − − +	+ + − − − − + + − + − + + − + +	+ + − − − + − +	− − + + + + − − + − − + − + + −	− − + + + + − − − + − + + − + +	+ + − − − − + + − + + − + − + +	+ + − − − − + + − + − + + − + +	+ + − − − − + + − + − + + + + + + + − +	+ + − − − − + + − + − + + − + + + + − +	+ + − − + + − + − + − + − − + + − − + −	+ + − − − − + + + + − + − + − +

* Numbers in parentheses refer to reference list.
† These percentages are derived, assuming a ratio of 78.42:14.03 for + + − − to − − + + forms, as in Column 5 ("Human Feces").
‡ The investigators classed these forms as irregulars and did not include them in the studies.

IMViC types from the individual samples. The number of types range from a minimum of four from EHC Endo medium (in the sample from the water treatment plant) to a maximum of nine from BGF medium (in the samples from the river and the creek). Cumulatively, each medium differentiates ten IMViC categories in essentially the same order of frequency. With both media, the two most common types are − − + + and + + − −, in that order. With EHC Endo medium, − + − + and − + + + types rank third and fourth, respectively, while the reverse is true with BGF medium. Thereafter, the frequency ranks of the various IMViC categories are identical until the tenth rank (representing one culture with each medium). This evidence supports the concept that EHC Endo medium and BGF medium are qualitatively and quantitatively equivalent in producing sheen colonies for a wide variety of IMViC types.

These results essentially agree with those reported by other investigators (*3, 4, 6, 7*) in the relative frequencies of the various IMViC types and in the number of IMViC categories represented (Table 5). In practically all instances, discrepancies in the frequency percentages are attributable to differences in the bacterial flora of the culture sources. Although the relative nonoccurrence of + − + + coliform organisms on membrane cultures may be due to scarcity of the type in the samples examined, there is also a possibility that the form does not grow well under the MF conditions provided in this study.

IMViC classifications of MF-cultured nonsheen colonies that produce gas in lactose are summarized in Table 4. Only 8 per cent of 135 − − + + colonies picked from EHC Endo medium fall into this group. This represents 3.1 per cent of the total number of coliform colonies (340 sheen plus 14 nonsheen) growing on this medium. On BGF medium, 10 per cent of 110 − − + + type coliform colonies did not develop a sheen, although fermenting lactose with gas production. Of the total number of coliform colonies (284 sheen plus 20 nonsheen) picked from BGF medium, this group of nonsheen-producing colonies represents 3.6 per cent.

The frequency of nonsheen-developing coliform colonies in IMViC categories other than − − + + is less with EHC Endo medium (0.8 per cent) than with BGF medium (3.0 per cent). This fact accounts for much of the slight discrepancy between EHC Endo medium and BGF medium in the productivity of differentiated (sheen) coliform type colonies—a discrepancy noted in the comments regarding quantitative results.

It is particularly noteworthy that all eleven of the IMViC types found in these samples did develop sheen colonies on the MF media, even though occasional colonies in some IMViC categories would not produce a sheen. This lack of sheen development by a few colonies not restricted to any one IMViC category is attributable to such factors as slow lactose fermentation or the low physiological vigor of some individual cells recovered from the original samples.

Summary

Six samples of water, chosen from sources known to contain several intermediate types of coliform organisms, as well as typical *Esch. coli* and *Aer. aerogenes,* were examined simultaneously by the MPN and MF methods. The results confirm earlier observa-

tions that the MF technique tends to give lower estimates of coliform density than the *Standard Methods* MPN procedure. It appears that the trend toward lower estimates by the MF procedure is due to variations in individual coliform organisms rather than to the selectivity of the method for particular coliform types.

Biochemical studies of 370 sheen-producing cultures isolated from EHC Endo medium confirmed 92 per cent of them as members of the coliform group. Of 300 sheen-producing colonies from BGF medium, 95 per cent were so confirmed. Only 4 per cent of 361 colonies producing no sheen on EHC Endo medium proved to be coliform types. Among 307 nonsheen colonies isolated on BGF medium, 7 per cent were coliform types.

Sheen-producing colonies from ten of the IMViC types grew on both media in essentially the same order of frequency. With both media, the two most common types were − − + + (*Aer. aerogenes* var. II) and + + − − (*Esch. coli* var. I), in that order.

From the data, it is evident that the great majority of coliform organisms growing on the membrane filter develop a characteristic "metallic" yellowish surface luster and subsurface color. It is equally evident that the great majority of colonies that do not develop the sheen and color are not coliform organisms as defined by *Standard Methods.*

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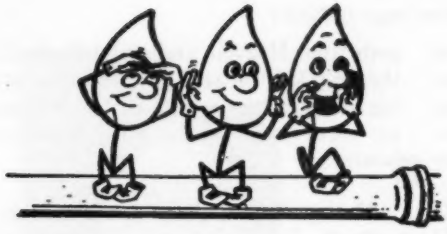

Percolation and Runoff

New legs for the water table were recently offered by Houston geologist A. Leonard Davidson in an inspired postulation of hydrologic countercyclism. Origin of all fresh water, according to this new theory, is the sea —an idea not necessarily different from presently accepted principles. But from there, where our hydrologic cycle heads up to the clouds, the Davidson direction is down, down to where "terrific pressure from the sea above forces water into the sands, two, three, five or more thousands of feet down," from whence it migrates upward, its salt being filtered out by the various strata through which it passes on its way to replenish the underground supplies we now tap. In this way, the sea forces up 90 per cent of our "spring water," rain making up the other 10 per cent as well as providing some incidental benefit ("often indirect") to surface water supplies.

Cited in proof of this proposition are records of "earth movements and pulsations," electric oil well logs showing salt water at the lower depths, knowledge that the same factors which cause tides cause corresponding movement in well waters, and a host of other rather difficult to appreciate data on sea and earth pressures at great depths and the specific gravities of "rock, shale, sand, clay, water, oil, and other bodies." If our concern for our friends in the sea-needy Plains States, or our pity for the rainmakers, or our confusion over Bermuda's drydom didn't make us just the least bit hesitant about getting off our present cycle, what would certainly give us pause is this disquisition on drought:

An understanding of this principle explains why the Houston fresh water table has lowered over the years. Since water and oil are both affected by this underground hydraulic force, their removal through thousands of wells has lowered the pressure and the top level has gone down more rapidly than it is being replenished. . . .

When springs seem to dry up during long drouths, it is not because of the lack of the rain directly. There is just as much water at the source as ever. What happens is that the dry weather has extracted moisture from surface soil. This, in turn, absorbs moisture from lower depths. As the spring water percolates through its subterranean channel or sands, it is absorbed into the drier earth. It just all gets absorbed before it reaches the mouth of the spring. Some springs never do dry up, although their quantity of water may be diminished.

At the root of our lack of confidence in Davidsonian hydrology, perhaps, is its similarity, if not actual coincidence,

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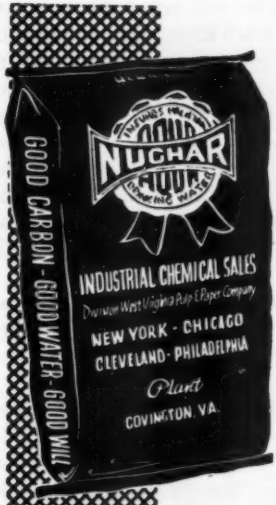
with Henry Gross' underworld of dowsing, in all its maze of pipes and domes and veins of water ascending from the bowels of the earth. Then, too, there is a familiar Grossness to the reasoning that "if rainfall had anything to do with" the water available in Saharan oases, "the springs might never have been there in the first place. They would certainly have dried up long ago." Even the recent Stevens-McCarthy "understanding" hardly prepares us for such harmoniousness of view between Kenneth Roberts' diviner and a reportedly "expert" *geologist,* oil though he be. At any rate we're definitely inclined to wait for the "clarification" of the theory as it was understandably misreported.

Meanwhile, let all be warned that we're prepared to fight to the last drop any suggestion that the stuff with which we work comes from hell's wells. On much better authority, we find it droppeth from Heaven, and certainly that's the only kind of stuff any self-respecting water works man would be willing to serve—at least during business hours.

Henry W. Hitzrot has been appointed director of the Water and Sewerage Industries and Utilities Div. of the Business and Defense Services Administration (BDSA), Dept. of Commerce. He is on six-month loan from the Dorr Co., which he served as special assistant for engineering sales. Shown below taking the oath of office from H. B. McCoy, deputy BDSA administrator (left of flag), Mr. Hitzrot succeeds Thomas T. Quigley (right), who returns to Wallace & Tiernan Inc. after completing his six-months' tour of duty. Mr. Quigley will continue to make his experience available to the division on a consulting basis.

(*Continued on page 36 P&R*)



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(*Continued from page 34 P&R*)

A safety training course will be held by the National Safety Council's Public Utilities Section during the week of May 10–14 for the benefit of safety directors for public utilities. The course will cover such material as job instructions, building a safe working force, accident reporting and analysis, motor vehicle safety, and labor relations. Details may be obtained from George MacDonald, staff representative, Public Utilities Section, National Safety Council, 425 N. Michigan Ave., Chicago 11, Ill.

A public relations strike with the hot iron set must be credited to Nelson Fuller, Batavia, N.Y., water superintendent, for his idea of offering free distilled water for steam irons to any customer who will bring his own container to the filtration plant—a come-on worthy of any pro promoter. Making the offer on his water bills, friend Fuller indicates that it is going over in a big way, bringing a lot of customers out to the plant, and sending them away not only happy with something for nothing, but at least a little more conscious of what's behind the water tap.

Now who will dream up free recarbonation? Or "Complete Water Service"? Maybe even fish!

Richard H. Gould, formerly director of the Div. of Sewage Disposal for the New York City Dept. of Public Works, has joined the staff of Greeley and Hansen, Chicago consultants.

(*Continued on page 38 P&R*)

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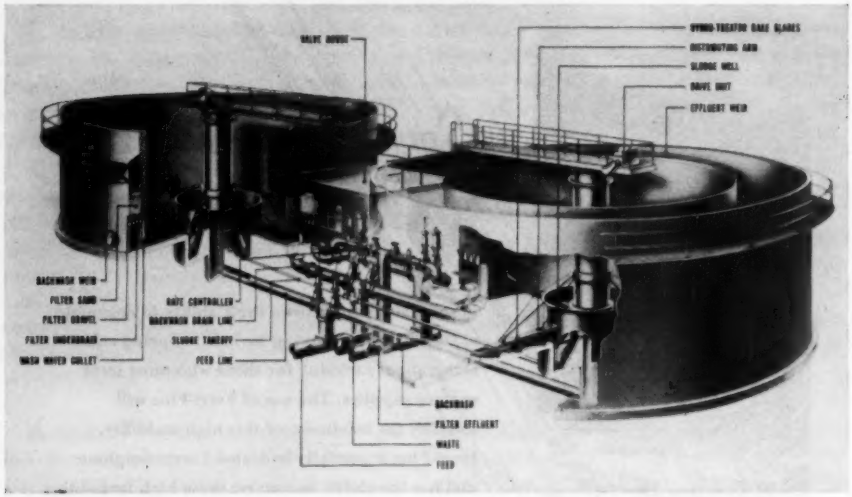
FREE—Let us send you without cost our new booklet on economical and efficient coagulation. Just send a card or letter to Tennessee Corporation, Grant Building, Atlanta, Georgia.

(Continued from page 36 P&R)



The Dorrco Aldrich PeriFilter System (above) is being produced by the Dorr Co. to provide package-type units for the pretreatment and filtration of water. After treatment is provided by a Dorrco Hydro-Treator (or, for some applications, a Clariflocculator or Clarifier), the water is filtered through the rapid sand filter on the periphery of the unit. Standard units are available in sizes ranging from 0.1 to 5.0 mgd. As with conventional filters, it is advisable to install at least two units in order to permit uninterrupted service during cleaning and backwashing.

Wallace & Tiernan Inc. is the name of the organization formed by the merger of the associated firms of Wallace & Tiernan Co. and Novadel-Agene Corp. Headquarters of the new firm will remain in Belleville, N.J.

The big way in which Texans do things has had a most interesting manifestation at Houston during the past few months, in the carrying out of the mayor's vow to connect every residence in the city to a sewer line, despite the fact that some of the residences are not yet connected to the public water system and despite the fact that others have no running water at all. The city health director finally decided that the completely dry places couldn't be forced to connect, but those with running water of any description were hooked up. Lest you wonder why not first things first, we need only remind you that with things going as they are in Texas these days, it won't be long before oil will be cheaper than water there—and oil, of course, is a natural for any kind of transportation. We can see those catalytic cracking plants now, where the trickling filters used to be. And every flush a gush!

Russell E. Rutan, formerly superintendent of the meter department for the Clarksburg, W.Va., Water Board, has joined the Neptune Meter Co. and will work in conjunction with Michael Siebert, Neptune's district representative in Maryland, Delaware, Virginia, and West Virginia.

(Continued on page 40 P&R)

How to Locate Water Leaks

WITH SIMPLEX PITOT EQUIPMENT

WHY not decrease your load and stop pumping to waste? Locate the hidden leaks which waste thousands of gallons per day per mile of main . . . far more than usually guess-timated!

Locating these leaks with Simplex Pitot Equipment costs only a tiny fraction of the value of the water being wasted. You get accurate flow records with minimum effort . . . valuable data that will help you to reduce "unaccounted-for water" to a minimum.

PITOT ROD

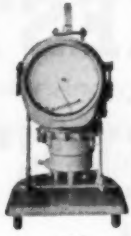
Simple, rugged and lightweight. Easily installed on any pipe or main. Special clamp holds tube firmly in position against water pressure.

Low coefficient gives high differential pressure for greatest accuracy.

MANOMETER

Quickly connects to a Simplex Pitot Rod with flexible tubing. You then have a simple, sensitive and inexpensive instrument for indicating rate of flow.

Can be used for wide flow ranges . . . low or high.



PITOT RECORDER

Connects easily to Pitot Rod. Eight-inch chart records flow data. Simple and rugged construction . . . no delicate mechanisms . . . yet sensitive and accurate.

Sturdy carrying case. Leveling feet. Reliable 7-day clock movement for chart. Accurately calibrated.

Get the Facts!

Free 20-page Technical Bulletin 1300. Full instructions for use and care of Pitot equipment. Seven pages of helpful formulae, tables, curves. Write to Simplex Valve & Meter Co., 6784 Upland St., Philadelphia 42, Pa.

SIMPLEX®

VALVE AND METER COMPANY

(*Continued from page 38 P&R*)

Postgraduate scholarships in public health are being offered at Harvard University, with awards ranging up to $5,000 for the 1954–55 academic year. Applications and a school catalog are obtainable from the Secretary, Harvard School of Public Health, 55 Shattuck St., Boston 15, Mass. The applications must be returned before April 30.

Edward B. Showell, senior consulting engineer on water and industrial wastes for E. I. du Pont de Nemours & Co., has retired after more than 35 years of service with the company, which began when he became superintendent of water for the firm's Hopewell, Va., plant in 1915. A former chairman of the Chesapeake Section of AWWA, he received its Fuller Award in 1952 and has also received a government citation for his work on the design of the largest industrial filtering and water conditioning plant in the world at the Hanford Engineer Works. He plans to undertake consulting work and may be reached at his home, R.D. No. 1, Chadds Ford, Pa.

Raymond B. Seymour has become president of Atlas Mineral Products Co. of Mertztown, Pa., succeeding George L. Wirtz, son of the firm's founder, shortly after Mr. Wirtz resigned to become chairman of the board. Seymour, who joined the firm in 1939 as chief chemist, has been executive vice-president and a director since 1949.

(*Continued on page 42 P&R*)

THE NON-LUBRICATED WATER-WORKS VALVE

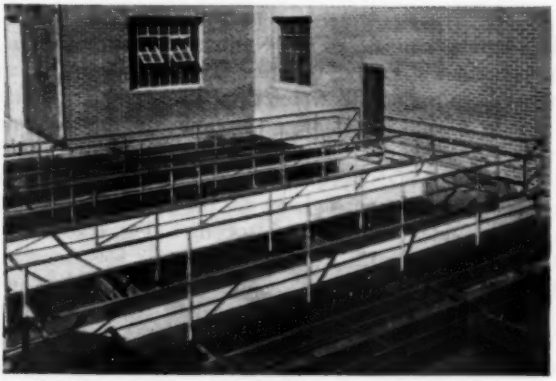
EASIEST TO OPERATE . . . EASIEST TO MAINTAIN . . .

DeZURIK PLUG VALVES

In water works services, DeZurik Valves in all sizes thru 20"—lever, gear or cylinder operated—open and close with remarkable, unfailing ease. They need only an e-a-s-y quarter-turn. They're easiest to maintain, too—no lubrication, no fussy adjustment—with a rubber-faced plug that closes drip-tight every time! Write for data.

DeZURIK SHOWER CO. SARTELL, MINNESOTA

Photo courtesy City of North Kansas City, Missouri



HOW NORTH KANSAS CITY *modernized* ITS IRON REMOVAL PLANT

To *triple* the 1912 rate of an old-fashioned settling basin and two filters could be a problem—and quite expensive.

Consulting Engineer Charles A. Haskins solved it very economically. Two compact, modern Permutit Precipitators were built into the *old* settling basin. Operating on the highly efficient sludge-blanket principle, these Permutit Precipitators assure maximum operating economy.

The results of this modernization—detailed in the table below—speak for themselves:

- Total Iron reduced from 5.0 to 0.1 ppm.
- Manganese reduced from 0.2 ppm to essentially zero.
- Turbidity reduced from 50 to only 3 ppm—permits 19 hour per day filter runs with washing only once every 5 days!
- Hardness reduced to level desired.

For full details on the Precipitator write to THE PERMUTIT COMPANY, Dept. JA-4, 330 West 42 St., New York 36, N. Y., or to Permutit Company of Canada, Ltd., 6975 Jeanne Mance St., Montreal.

Registered Trade Mark

Water Analysis Report Before and After Conditioning

			PPM as	Raw Water from wells before aeration	Precipitator effluent (unfiltered)
CATIONS	Calcium	(Ca++)	$CaCO_3$	145	55
	Magnesium	(Mg++)	$CaCO_3$	103	75
	Sodium	(Na+)	$CaCO_3$	108	105
ANIONS	Bicarbonate (Alkalinity)	(HCO_3−)	$CaCO_3$	190	42
	Carbonate (Alkalinity)	(CO_3−−)	$CaCO_3$	0	24
	Hydroxide (Alkalinity)	(OH−)	$CaCO_3$	0	0
	Chloride	(Cl−)	$CaCO_3$	35	35
	Sulfate	(SO_4−−)	$CaCO_3$	146	139
	Total Hardness		$CaCO_3$	248	130
	Alkalinity A (Methyl Orange)		$CaCO_3$	190	66
	Alkalinity B (Phenolphthalein)		$CaCO_3$	0	12
	Free Carbon Dioxide		CO_2	16	0
	IRON (total)		Fe	5.0	0.1
	Silica		SiO_2	16.8	13.0
	MANGANESE		Mn	0.2	0.0
	TURBIDITY (after shaking)			50	3
	Fluorides		F	0.5	0.4
	Color			Turbid	5
	pH			7.3	9.5
	Total Hardness (as $CaCO_3$)		Result in grains per U.S. Gal.	15	7.6

PERMUTIT® WATER CONDITIONING HEADQUARTERS FOR OVER 40 YEARS

(Continued from page 40 P&R)

The safety contest of the National Safety Council's Public Utilities Section has been opened to water utilities for the first time, beginning with the current or 1954 contest. All water utility members of NSC are eligible to compete in the water division of the contest, provided registration is completed before May 15. Contest rules and registration forms may be obtained from the Council. Awards will consist of a plaque, second- and third-place certificates, and special certificates for honorable mention or achievement. To the 17 water works which have already enrolled, the rest of us may wish, not good luck—safety is not a matter of luck—but "good work" or, even better, "good habits!"

William E. Smith has been appointed assistant sales manager of the Dorr Co., Stamford, Conn. He is succeeded in his former post of manager of North American sales by Glenn O. Wilson, previously manager of the Western Industrial Div. William T. Marston takes over the latter position.

Tracer in the chaser really stirred things up in Virginia City, Nev., last December, when Hobart Leonard, water company manager, dropped some green vegetable dye into the tank feeding the town's nonpotable fire system to check on the possibility that some residential plumbing was hooked up to it rather than to the separate drinking water system. Results, if the local newspaper is to be believed, were rather more violent than intended—frightened flushers rushing to their doctors, barflies going on the wagon and sober citizens taking to drink, while rumors spread that the new 100,000-gal tank at the edge of town, salvaged from a cyaniding mill, was poisoning the populace. Out of the excitement came the discovery that eight domestic services were connected to the fire lines, probably a hangover from the casual plumbing practices at the turn of the century, when no one in Virginia City used chasers, much less tracers.

Misconnections, though, aren't the water company's only hangovers from the excesses of the city's past. Having inherited a water system designed to serve a population of 40,000–50,000, the company now has fewer than a thousand to serve in Virginia City and is prevented, by a public utilities commission order, from discontinuing that service. Since the heyday of the city during the strike at the Comstock Lode, back in the 1870's, the utility has managed to pull in its expensive horns just a little by removing two of the three transmission lines that were built to carry the supply from the neighboring Sierra Nevada across Washoe Valley by siphon and up to Virginia City. One of these lines of combined flume and riveted steel pipe was sold for scrap to raise money for other operations; the piping portion of the other was used to replace old flume that carried the supply from "five-mile" reservoir into the community. So now manager Olmstead's only transmission worries involve holding the present line together, keeping it from freezing in the rugged winters, and trucking in water when the freeze-up can't be prevented.

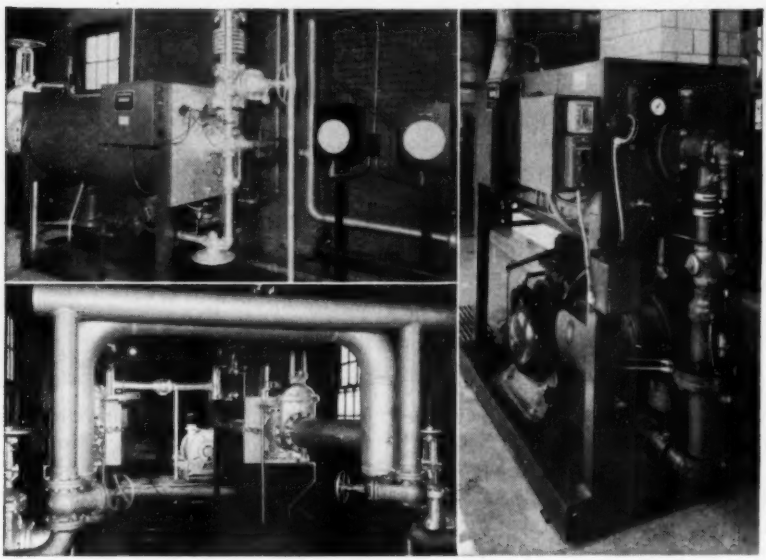
But wait till they strike uranium!

Kenneth H. Larkin & Assoc., consulting engineers of Kansas City, Mo., have just occupied new quarters at 19 E. Gregory Blvd. The new office building was designed and constructed by the firm for their own use.

(Continued on page 44 P&R)

CARBALL UNIT...

SPECIFICALLY DESIGNED FOR THE CLEAN, EFFICIENT CARBONIZATION OF LIQUIDS



- A CO_2 producer that *COMPLETELY* burns GAS or OIL.
- Produces the highest percentage of CO_2 gas with no CO or condensible carbon.
- Completely eliminates oil scum . . . no taste imparted to potable waters.
- No scrubbers or filters required.
- Compressor handles clean, cold air only. The fuel is burned under sufficient pressure to cause deep diffusion directly from the producer.
- Diffuses CO_2 gas by efficient Diffusair system, insuring complete absorption.
- A factory-tested, package unit with air compressor, fuel pumps and appurtenances.
- 50% more chemical efficiency than any other method in current practice.

To Reduce Costs and Modernize Your Plant:

WRITE FOR BULLETIN 7W64

WALKER PROCESS

WALKER PROCESS EQUIPMENT INC.

FACTORY • ENGINEERING OFFICES • LABORATORIES

AURORA, ILLINOIS

(*Continued from page 42 P&R*)

The 50th state in the United States of AWWA isn't quite a reality yet, but with Alaska brought into the Union as part of the Pacific Northwest Section in January, and with Hawaiian members granted full participation in the California Section as long ago as 1951, the AWWA Board of Directors is way ahead of that somewhat similar, slower group working on the same project down in Washington. As a matter of fact, with the Southwest Section driving so hard to take membership honors away from California, we'll be quite surprised if Mexico, Central and South America don't petition to join their amigos of AWWA's Southwest long before we have to worry about sewing any new stars in our flag. That's water though—the universal solvent!

The age of water is upon us. Only trouble is, the "age" seems everywhere prefixed by such difficulties as "short" and "out." Latest area to join the Southwest and the Northeast in the bout with drought is the Midwest, where, particularly in Kansas, Nebraska, and Missouri, new records of dryness are being established and shortages and outages are multiplying with every unrainy day. At Springfield, Mo., for instance, where the last real rain was 8 months past, conservation measures as well as the help of a rainmaker have been called upon. And at Olathe, Kan., 300,000 gpd was being imported by tank car from Kansas City, Mo., after the Olathe lake level had dropped below the city's intake. In the Southwest and the Northeast, meanwhile, though the situation was not at the very worst ever, it was anything but encouraging—New York City's reservoirs, for instance, having dropped to the lowest level since the near calamity of four years ago.

Against this background, the advertisements of Charleston, S.C., and Auburn, N.Y., stand out like mirages. "Water! Water! Water! 10 Billion Gallons of soft fresh water a day —*every day*" is Charleston's come-on to industry in such media as *Business Week* and the *Wall Street Journal.* "No Water Shortage Here" was Auburn's trump card in its drive to replace the loss of its industrial mainstay, International Harvester, by other manufacturer-employers. And its advertising of an "inexhaustible water supply direct from Owasco Lake" not only made up the jobs lost, but more than doubled the number and added diversity by bringing in four employers to replace the one.

The age *for* water anyway!

(*Continued on page 46 P&R*)

Closeout Sale! **$5.95** (Published at $7.50)

Manual of British Water Supply Practice

Compiled by the Institution of Water Engineers, London. Over 900 pages

This offer good only in the United States and while the supply lasts. Payment in advance required.

American Water Works Association, Inc.
521 Fifth Avenue New York 17, N.Y.

MANHOLE STEPS:

GIVE THEM AN EXTRA MARGIN OF SAFETY WITH CORROSION-RESISTANT EVERDUR

Manhole steps—of all sewage treatment and waterworks structures—need *extra* corrosion resistance and dependability. Everdur* gives it to them . . . and adds the strength that really pays off . . . in greater safety.

Everdur Copper-Silicon Alloys deliver the same corrosion resistance—*plus ease and economy of operation over the years*—to gates, screens, guides and bolts, weirs, float chambers, troughs, stems and electrical conduit. Everdur is easily fabricated into lightweight, built-up wrought-metal assemblies.

Depending on type or composition, Everdur Alloys can be worked hot or cold. You can form, forge, weld and machine them. They are available in the form of plates, sheets, rods, tubes, electrical conduit and casting ingots.

Write today for Anaconda's free booklet, "Everdur Copper-Silicon Alloys for Sewage Treatment and Waterworks Equipment." For specific help in selecting the right alloy for your equipment, consult our Technical Department. *The American Brass Company, Waterbury 20, Connecticut. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.* S2140A

*Reg. U. S. Pat. Off.

EVERDUR
ANACONDA®
COPPER-SILICON ALLOYS
STRONG • WELDABLE • WORKABLE
CORROSION-RESISTANT

(*Continued from page 44 P&R*)

The Sanitary Engineering Center is the new name for the Cincinnati, Ohio, laboratories of the Public Health Service, previously known as the Environmental Health Center.

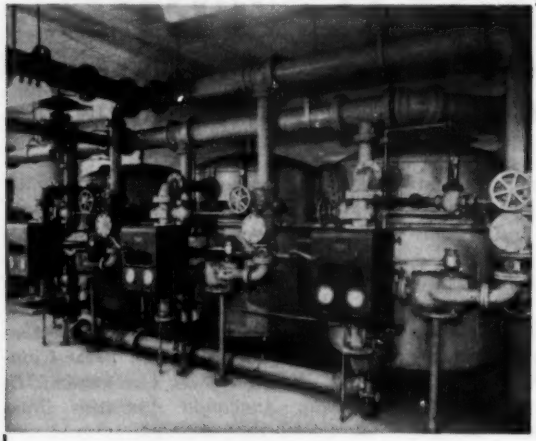
Louis F. Frazza has been appointed manager of district sales operations of the newly created Marketing Section in Johns-Manville's Transite Pipe Dept. He will be assisted by Otto A. Wirsig, staff manager.

Golden-Anderson Valve Specialty Co. has moved its general offices to new and larger quarters at 1232 Ridge Ave., Pittsburgh 33, Pa. The engineering staff has been doubled and production facilities modernized and enlarged to meet the increased demand for its products.

Sulfite liquor waste from paper mills may lose its standing as a stream pollutant and begin to perform useful work, according to a discussion at the Highway Engineering Institute held at the University of Wisconsin last February. The spent sulfite liquor has been used to rehabilitate bituminous roads. After an initial softening, the repaired surface is said to harden and cure rapidly. Tests of the procedure are being sponsored by the Sulphite Pulp Manufacturers Research League, Appleton, Wis.

Glenn Hawkins has been appointed a Builders-Providence application engineer, assisting R. W. Pearce, for chlorination installations. He was formerly with American Water Softener Co.

(*Continued on page 86 P&R*)



WATER PROBLEM?

Photo on left shows a typical H & T fully automatic, municipal, zeolite water softening plant producing clear, iron free, soft water.

Operation of this automatic water treatment plant is by our electrically operated *poppet* type multiport valves—the valves which provide unequalled performance.

If you have a water problem of any size or type—write us. With over 50 years of experience—conditioning water—We Can Help You

A New Bulletin of Bulletins . . . FREE on Request

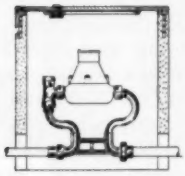
H&T SERVICE

HUNGERFORD & TERRY, INC.

CLAYTON 5, NEW JERSEY

To Simplify

OUTDOOR METER SETTINGS



With a Ford Coppersetter, or a Ford Linesetter, you can eliminate as many as six pipe joints, two risers, four ells, one pipe coupling, one meter coupling and possibly a valve. In so doing, you raise your meter from 3″ to 36″ above your service line, depending upon the model used. Positive alignment is maintained when meters are changed.

Copper and bronze construction add extra years of life. Hydraulic efficiency is improved.

The economy is obvious . . . . and the savings are real. Send for free catalog. It contains complete information.

FOR BETTER WATER SERVICES

FORD

THE FORD METER BOX COMPANY, INC. Wabash, Indiana

The Reading Meter

The Story of Water Supply: *A trip behind your water faucet. American Water Works Assn., 521—5th Ave., New York 17, N.Y. (1954) 16 pp.; paperbound; 15¢ (quantity prices on request)*

Appropriately designed as a four-color picture booklet, this educational aid to an enlightened public relations campaign explains to schoolchildren the many factors that go into providing a safe, adequate, and dependable water supply. Intended for distribution by local water utilities and other groups with a professional or business interest in the subject, the booklet uses Willing Water, the ostensible author, to describe the history, principles, and workings of water supply systems. It is ideal for use in junior high school science classes and on plant inspection tours, and may also be distributed to advantage in doctors' waiting rooms, barber shops, and the utility's business office. A companion teacher's manual is planned and will be prepared later.

A brief tour is made of the water systems of antiquity, with due attention to such engineering achievements as the Roman aqueducts and to such early purification discoveries as those of boiling, settling, and filtration. The historical summary is completed with an account of how modern filtration and chlorination practices finally made water truly safe to drink.

Simplified yet technically accurate discussions of such basic mechanisms as that of the hydrologic cycle and ground water flow prepare the reader for a brief outline of present-day collection, treatment, and distribution systems. A final page deals with the importance of leak prevention and the proper way to read a water meter.

Energy in the Future. *Palmer Cosslett Putnam. D. Van Nostrand Co., Inc., 250—4th Ave., New York 10, N.Y. (1953) 556 pp.; $12.75*

Looking forward to the "market" for nuclear fuels in the next 50 to 100 years, the Atomic Energy Commission assigned a consulting engineer to study the maximum plausible demands for energy in that period, as well as the degree to which other fuel and energy systems could be expected to meet those demands. It is a tribute to the author that this stimulating and readable volume is not a popularization of his report—it is the report itself.

If we refrain from using the word "enjoyable" in describing the work, it is only because the content is so disturbing. And it might be appropriate to observe here that the chapter on population growth (Mr. Palmer's word is "explosion") will have a special and unhappy fascination for any water resources prophet—local or global.

It is clear from Mr. Putnam's impressive study that if we are to avoid disaster we must do more than just control the military use of nuclear energy. We must exploit its peacetime capabilities also—not just so the caretakers of the atom won't get into mischief, but because we will soon be faced with a desperate need. Unless we can begin to make real use of nuclear fuels soon (before 1975, in the U.S.), and to convert at least 60 per cent of our energy-using systems to be powered by such electricity or heat, the cost of other types of power will rise so

(*Continued on page 50 P&R*)

COMPLETE..VIOLENT..INSTANT..UNIFORM

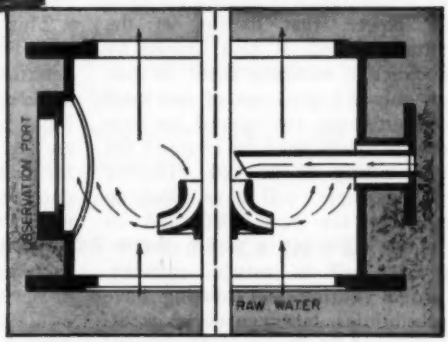
American HOMOMIX CHEMICAL MIXING without a Mixing Tank

2-stage Homomix

The HOMOMIX gives instantaneous, violent, and uniform mixing of one or more chemicals, or gases, with water. *Immediate, total diffusion*—the most important factor for the efficient and economical addition of chemicals or gases—is obtained *without the use of a mixing tank!* For new plants it eliminates the necessity for costly mixing tank construction; for existing plants it can be effectively used to improve treatment.

The HOMOMIX, in one or more stages, is installed in, and forms part of, the piping. Diffuser impellers rotate in blending chambers and discharge directly across the flowing-through stream. Each chamber has one or more chemical inlet connections and a transparent plastic observation port through which the mixing action is visible. A lifting stage can be provided for additional head, if required.

Write for "Technical Supplement HM" . . . Complete Design Data



(PATENTED)

Working Model on Display in Booth 67–68 A.W.W.A. Convention Seattle, Wash. *May 23–28*

AMERICAN WELL WORKS

IN OUR 68TH YEAR
112 North Broadway
AURORA, ILLINOIS

Pumping, Sewage Treatment, and Water Purification Equipment
RESEARCH · ENGINEERING · MANUFACTURING

Offices: Chicago • New York • Cleveland • Sales Representatives throughout the World

The Reading Meter

(Continued from page 48 P&R)

sharply as to dislocate present economic frameworks.

It is not just that our reserves of traditional fuels are limited. "Reserves are relative," points out Mr. Putnam. "There is more coal, oil, and gas in the earth's crust than will ever be used. It is not a question of emptying the bin. It is only a question of deciding how deep it is economical to dig." Abundant facts on our endowed capital of fossil fuels, fortified with tables and charts, indicate that the diggings face a decline.

As for renewable, or "income" sources of energy, Mr. Putnam predicts they will meet no more than 15 per cent of our needs, despite the fact that the sun daily distributes energy equivalent to more than two tons of coal on every acre in the U.S. Conventional utilization of this energy by means of fuel wood, farm wastes, and peat can never take up much of the load. Nor can improved methods of harnessing the winds, tides, waves, and such other possible energy sources as the temperature differences to be found in tropical waters. Economically feasible sites are too scarce.

Water power, that darling of the conservation-minded, is also limited by the economics of available sites. It now provides only 0.7 per cent of our total system requirement, and against the gain from new projects must be charged the loss from silting of the old. Hoover Dam, for example, will have filled up completely by the year 2080, and its power plant will then be a run-of-river generator, at half its installed capacity. Direct solar heating and cooking have some possibilities, but require an excessive investment in facilities to provide storage against weather fluctuations. The breeding of algae has some possibilities as a food source, but offers little hope as a major or even economical fuel producer. To depend mainly upon solar energy, in short, is to accept a forty-fold increase in power costs.

By contrast, nuclear fuels promise a plentiful supply of heat or electric energy, at a cost range of no more than twice that of coal today. Nor are we limited to the comparatively rare, concentrated sources of uranium or thorium, which are relatively plentiful in dispersed form. The uranium even in a ton of granite, for example (although admittedly uneconomical in that form), has a greater heat potential than a ton of coal.

If we learn to control nuclear fusion as we can control nuclear fission, the hydrogen in a single cubic mile of sea water may provide an economical source of enough energy for the world for centuries. But the job, not just of perfecting nuclear power plants, but of converting our present power-using equipment to make use of the new energy, is staggering. There's work to be done.

Fresh Water From the Ocean: *For cities, industry, and irrigation. Cecil B. Ellis et al. The Ronald Press Co., 15 E. 26th St., New York 10, N.Y. (1954) 217 pp.; $5*

This study, sponsored by the Conservation Foundation, took as its object the determination of the most economical method, over a 30-year period, of extracting 1 bgd of water suitable for drinking and irrigation from the ocean off California or Texas. The course of the inquiry ranges the entire known field of methods for sea water reclamation, from conventional distillation and ion exchange procedures through a bewildering array of sieves, charged-net membranes, electro-osmosis devices, and the like. Close attention is paid to energy transfer calculations, both theoretical and empirical, and the various methods are systematically treated as examples of applying basic forces, such as gravity, electricity, heat, refrigeration, and the like. The author's

(Continued on page 52 P&R)

Wide World Photo

this could happen in your town

THIS CITY STREET CAVED IN when a water main broke. It's a dramatic, but not an unusual example of what water does to road bedding. Protect your roads and pipes from the problems of leakage by Centrilining. This patented process thoroughly cleans and centrifugally lines pipes with cement mortar. Leakage, tuberculation and interior corrosion are permanently checked . . . carrying capacity and distribution pressure are increased to "better than new" highs. And the whole process is done with pipes in place . . . no excavation . . . no traffic disruption. With Centrilining you can save your water mains . . . and streets too.

Write today for free booklet

CEMENT-MORTAR LININGS FOR PIPES IN PLACE

3,000,000 FEET OF EXPERIENCE

CENTRILINE CORPORATION

A subsidiary of Raymond Concrete Pile Co.

140 CEDAR STREET, NEW YORK 6, N. Y.

Branch Offices in Principal Cities of United States and Latin America

The Reading Meter

(Continued from page 50 P&R)

somewhat hopeful conclusion points to the electric membrane method as potentially the cheapest, and predicts that in perhaps ten years the cost of extraction will have been reduced to 30¢ per 1,000 gal at minimum power costs. This is considered feasible for industrial or municipal use, but not for irrigation. Distillation methods—particularly compression distillation—are considered second best for small installations (1 mgd or less), with a predicted minimum cost of 70¢ per 1,000 gal.

Statistical Summary of Water Supply and Treatment Practices in the United States. *John R. Thoman. PHS Pub. 301, Div. of Water Pollution Control, Public Health Service, Washington, D.C. (1953) 53 pp.; paperbound; 20¢ from Government Printing Office, Washington 25, D.C.*

This most complete and accurate summary of water supply statistics available is based on a 1948 inventory of water and sewage facilities. Thus there is considerable authority behind the statement that 93,455,135 persons in 16,747 communities are served by public water supplies. Of these, 74.4 million receive treated water, 10.3 million are in communities receiving a combination of treated and untreated water, and 8.7 million receive untreated water only. A total of 6,986 treatment plants serve 83.3 million persons of the 93.5 million total. Extensive tabulations give detailed breakdowns by population groups, regions, and types of treatment.

(Continued on page 54 P&R)

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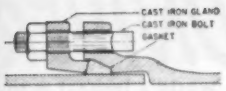

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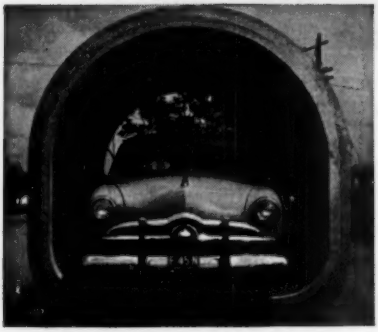

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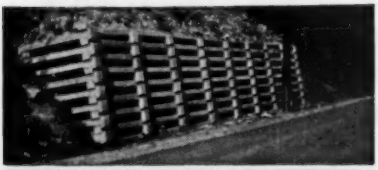

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The Reading Meter

(*Continued from page 52 P&R*)

What Is Hard Water? *Cornelia A. Tyler. Water Conditioning Research Council, 111 W. Washington St., Chicago 2, Ill. (1953) 30 pp.; spiral bound; $1.75*

Although primarily intended to "sell" domestic water softening, this booklet is factual and comprehensive. In detailing the practical and economic basis for domestic softening, the author has made effective use of comparative photographs and tables. Probably the weakest link in the logical chain is the insufficient attention that is paid to the steady replacement of soap by synthetic detergents (syndets) for home laundry and dishwashing operations. Despite indications that even syndets perform better in softened water, economic calculations lose much of their relevance when they are based on the exclusive use of soap.

Syndets have finally captured the bulk of the packaged detergent market, and this revolution in home economics has gone so far that users of automatic laundry and dishwashing appliances are turning to the industrial type of nonsudsing syndet that it was once thought impossible to offer to the housewife. Furthermore, some appliances even have attachments for injecting compounds like Calgon into the rinse water, thus stealing some thunder from another of Dr. Tyler's arguments.

On the whole, however, the booklet presents a convincing and interesting account which any educated layman can follow.

Errata Sheet for "Industrial Wastes: *Their disposal and treatment.*" *M. G. Burford, Hall Laboratory of Chemistry, Wesleyan Univ., Middletown, Conn. (1954) 1 p.; free*

This errata sheet corrects errors in the numbering of references for the section on plating wastes of No. 118 of the American Chemical Society Monograph Series (*see* "Reading Meter" for July 1953, page *50 P&R*).

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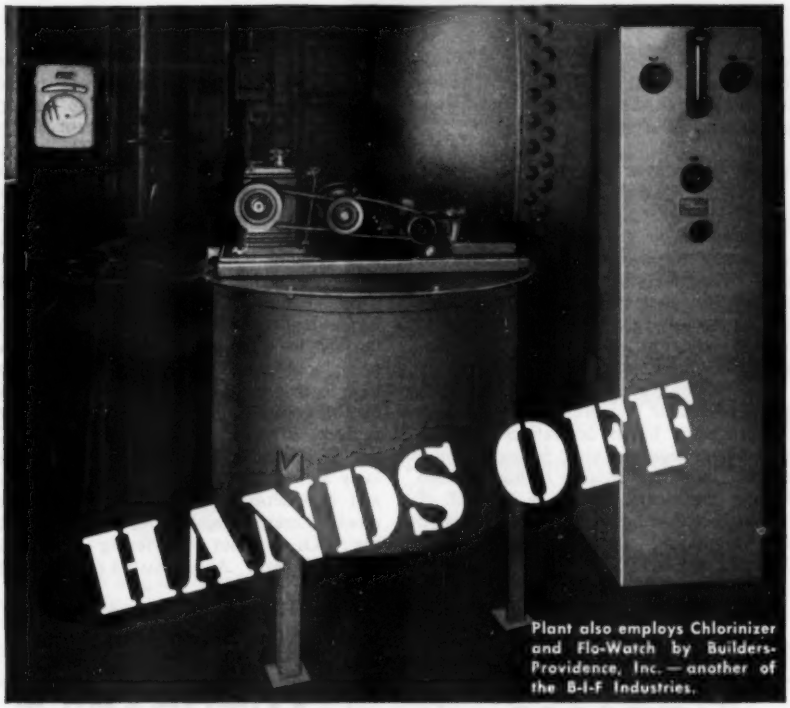
Key: In the reference to the publication in which the abstracted article appears, 39:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, 39:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *BH—Bulletin of Hygiene (Great Britain); CA—Chemical Abstracts; Corr.—Corrosion; IM—Institute of Metals (Great Britain); PHEA—Public Health Engineering Abstracts; SIW—Sewage and Industrial Wastes; WPA—Water Pollution Abstracts (Great Britain).*

CHEMICAL FEEDING, CONDITIONING, AND SEDIMENTATION

Mixed-Bed Versus Two-Step Demineralization of Boiler Feedwater. M. E. Gilwood & C. Calmon. Can. Chem. Processing, 37:7:36 ('53). To prevent contamn. of steam with SiO_2 and subsequent deposition on turbine blades, SiO_2 in boiler saline at pressures above 1,000 psi should be less than 5 ppm. At pressures of 1,800–2,000 psi or higher, max. SiO_2 permitted is sometimes less than 1 ppm. Common, therefore, to specify concn. not greater than 1 ppm in makeup water. 2-step demineralization, with intermediate degasification to remove CO_2 between hydrogen cation-exchange unit and strongly basic anion-exchange unit, permits production of water with low total-solids and SiO_2 content. Further development is mixed-bed unit, cation and anion exchangers being sepd. hydraulically before regeneration. In this process, CO_2 must be removed by anion-exchange resin. Both processes produce water with electrolyte content of 5 ppm or less and SiO_2 content of 0.1 ppm or less. Parallel tests made with water contg. 118 ppm alky. and 16 ppm SiO_2 using same cation- and anion-exchange resins in mixed-bed and 2-step demineralizers. In latter, Na leakage through cation exchanger should be reduced to min. to secure best SiO_2 removal (to 0.01 ppm). Such removals effected with 6 lb NaOH/cu ft for regeneration. With mixed bed, 10 lb NaOH/cu ft needed to obtain similar results. Also, SiO_2 removal efficiency decreased with increasing age of mixed bed. Total exchange capac. of anion exchanger lower in mixed bed because of absence of intermediate CO_2 removal. Low-SiO_2 effluents more easily obtained by 2-step process when ratio of SiO_2 to total anions in anion exchanger influent less than 1:5, but even with 1:1 ratio, 0.01 ppm SiO_2 can be maintained by proper control. As ratio less in mixed-bed demineralization because of CO_2, one would expect SiO_2 to be removed more readily. This was not borne out by expts. Economic considerations indicate mixed-bed demineralization should be considered when treating water of low total-solids content, i.e., 30–75 ppm. Above this, 2-step process seems preferable. If Fe present, addnl. costs incurred if mixed-bed method employed.—*R. E. Thompson*

Demineralization—Makeup Water for Steam Power Plants. J. D. Yoder. Southern Power & Ind., 71:5:74, 114 ('53). Most economical means of prepg. makeup water for high-pressure boilers is demineralization procedure with cation and anion exchangers, except for highly saline waters, where distn. is only available procedure. Examples of several recent installations in steam plants given. Water is preferably treated first in cation exchanger, by using material such as sulfonated styrene type resin or sulfonated, granulated, and suitably prepd. bituminous coal. Both materials are usually regenerated with H_2SO_4. With carbonate-contg. waters, effluent from this exchanger contains CO_2, which is more economically removed by means of aerator or vacuum deaerator than by anion exchange. Anion-exchange material is highly basic resin that removes both strongly and weakly ionized acids. Regeneration is by use of NaOH. Both cation- and anion-exchange materials are placed in separate rubber-lined tanks. Higher degree of demineralization can be secured by use of mixed cation-anion bed, but this is more expensive with carbonate-contg. waters and regeneration procedure is more involved. Demineralized water is somewhat corrosive to steel; if it is to be handled in steel, pH should be increased to 9.2 by addn. of NaOH soln.; this is especially important with mixed-bed demineralization. Internal coating may also be used in pipes and containers. Less expensive to remove bicarbonates than sul-

(*Continued on page 64*)



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(*Continued from page 62*)

fates; with same mineral salts, it would cost only half as much to demineralize water contg. 250 ppm as one contg. 500 ppm. Flow diagrams and illustrations given.—*CA*

Modern Feedwater Treatment Practice. E. R. WELSH. Can. Chem. Processing, **36**: 12:32 ('52). Deaerating heater, by removing noncondensable gases, reduces feedwater corrosiveness. Subsequent pH adjustment usually eliminates pump and feedline corrosion. Na_2SO_3, preferably catalyzed, in addn. to instantaneously removing last traces of O, serves as guide to efficiency of deaerating equip.—inefficiency immediately accompanied by need for higher dosage. Org. materials stabilize feedwater and prevent scaling; specially processed lignin derivatives most effective. Corrosion and scale formation more acute in economizer because of higher temp. Softening chemicals should be applied directly to boiler drum to prevent deposits in feeder regulator; also, this arrangement makes possible control of feed to individual boilers. Phosphate frequently used for softening. $Ca_3(PO_4)_2$ relatively easy to hold in suspension. $Mg_3(PO_4)_2$ tends to settle and to bind otherwise nonadherent sludges. High alky. ppts. Mg as $Mg(OH)_2$, or SiO_2 may be added to form Mg silicate; either causes less difficulty than phosphate. Lignin derivatives especially effective in conditioning boiler water sludge. Fe oxide also sticky type of solid, tending to settle and bind normally suspended sludge. In absence of appreciable amts. of other solids, it forms dense insulating coating of magnetic Fe oxide, leading to tube failures. Fe oxide should be reduced to min. in feedwater. Continuous blowdown widely used for controlling concn. of dissolved and suspended solids but cannot replace effective manual blowdown. CO_2 and O render condensate corrosive, particularly at low pH, leading to high Fe content and destruction of return lines and equipment. Certain amines effective in neutralizing CO_2 without interfering with other chemicals used. Amine flashes off with steam

(*Continued on page 66*)

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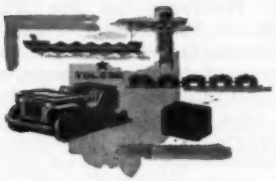

Toledo engineers prefer concrete pressure pipe for the city's water supply mains. In 1948 an 8,600-foot installation, known as the Bancroft Street Crosstown Main, was completed. Since then 24", 36", 48" and 72" concrete pressure pipe has been used in major additions to the city's water supply system. Just recently contracts have been signed by Lucas County authorities and work is in progress on additional projects in the Toledo area, involving 16" and 24" pipe.

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(*Continued from page 64*)

and condenses with condensate, forming amine bicarbonate and raising pH. Amine bicarbonate decomposes in deaerating heater, CO_2 escaping to atm. and amine returning to boiler in feedwater. Filming materials also used to protect return lines, but these may foul jet evacuator system in condensing turbines or impair sludge conditioning. Amines have none of these disadvantages, but there are economic limitations; with makeup of harder waters above 40%, filming chemicals may be more economical. Pretreatment will remove practically all scale- and sludge-forming compds.—*R. E. Thompson.*

Use of Amines in Low-Makeup Steam Plant. H. J. GUILLORY. Southern Power & Ind., **71**:7:50, 82 ('53). High CO_2 and Fe pickup were noted in No. 3 boiler-turbine unit. Condensate is used entirely for boiler feedwater, small makeup (about 1%) being supplied from bent-tube evaporator provided with internal treatment. Cond. of condensate at hot well was 1.5–2.0 micromhos, while steam samples at boiler drum, corrected for gases, ran about 0.4–0.5 micromhos. Analysis of condensate showed 3.0–3.5 ppm CO_2 in spite of excellent deaeration facilities. Use of acid-regenerated zeolite filter reduced CO_2 at deaerator discharge from approx. 3.5 to 1.5 ppm, while pH values at this point were increased from 6.3–6.5 to 6.6–7.0. Various possibilities of further decrease of CO_2 were considered, but use of morpholine type amine was instituted. While lignin deriv. and catalyzed Na_2SO_3 were being added to deaerator discharge pipe, amine was added with this mixt. at rate of about 500 ml/day (boiler unit was rated 120,000 lb/hr). After about 2 mo. amine dosage was gradually decreased to 100 ml/day amine, added to chem. feed tank. pH of deaerator discharge was increased to approx. 8.6. With this low feed of amine, NH_3 is present as trace and Fe content of deaerator discharge is 0.1 ppm or less. Fe content of boiler water was stabilized at less than 1 ppm. In new plant, complete demineralization (exchange) will be used for makeup, and amine will not be used unless necessary.—*CA*

The Use of Phosphates in Municipal Water Treatment. L. W. HAASE. Gesundh.-Ing., **73**:404 ('52). Formation of thin, insol., double-salt *o*-phosphate scales, e.g., $FeCa_3(PO_4)_2$ and $Al_2Ca_3(PO_4)_4$, prevents corrosion. Formation of these salts is favored by low *o*-phosphate concn. pH of water is not important. Polymetaphosphates are responsible for temporary removal of hardness and prevention of scale formation, *o*-phosphates being formed in time by hydrolysis. Pyrophosphates have no value in water treatment. Phosphates in soln. should not exceed 8–10 ppm P_2O_5 for health reasons. Phosphates in greater quantity have detrimental buffering effect on stomach acidity.—*CA*

Water Treatment by the Threshold Method. C. RIESS. Mitt. Chem. Forsch-Inst. Wirtsch. Osterr. (Austria), **7**:1 ('53). Advantages of phosphate treatment, especially use of polymeric phosphates in substoichiometric amts. (threshold method or "phosphatinpfoerfalven"), for prevention of stony scale formation and incrustation where water is not heated to boiling are described. Curves are given for influence of metaphosphate on pptn. and stabilization of $CaCO_3$ hardness. Ultramicroscopic studies have shown that $CaCO_3$ does not pass into colloidal state. Colloidal state is not stabilized by phosphates. Ppts. contain Ca and P in almost const. ratio of 300:1 for application of more than 0.6 ppm metaphosphate. In prepn. of leather, metaphosphate treatment has prevented cryst. pptn. of $CaCO_3$ after depilation in alk. bath and rinsing with water, even medium hard.—*CA*

Inhibitors for Eliminating Corrosion in Steam and Condensate Lines. R. C. ULMER & J. W. WOOD. Ind. Eng. Chem., **44**: 1761 ('52). Two types of treatment have been advocated to control corrosion due to steam condensate: introduction of alk. substances to neutralize acidity and of film-forming substances to coat metal. Corrosion test data were obtained with condensate from 600-psi boiler with representative materials of both types. In general, type that neutralizes acidity was found to give best results. When condensate pH was raised to around 8.0, Fe corrosion was negligible. Film-forming materials decreased corrosion rate, but not to as great extent. With both types rate of corrosion was found to increase with higher concns. of dissolved O; this was also true with controls. Both types give

(*Continued on page 68*)

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(*Continued from page 66*)

good results with Cu and brass. In selecting treatment for given instance, consideration must be given to metals in system and DO content of condensate.—*CA*

Caustic Cracking in Steam Boilers—Caustic Cracking of Boilers in the United States. A. A. BERK. Chem. & Ind., p. 360 ('53). Review is given of history of caustic cracking, development of embrittlement detector, and means for preventing caustic cracking. $NaNO_3$ is outstanding treatment for preventing cracking. While quebracho tannin is used extensively, it is not always effective, especially at higher operating pressure. Zero-caustic treatment is only method suited for high pressures (1,000 psi or higher). Records of 30 instances of caustic cracking, in which intercryst. cracks appeared, indicated only one occurrence of cracking in the presence of $NaNO_3$—presumably due to high NaOH concn. with little $NaNO_3$. In no other instance was nitrate or tannin type inhibitor present in concns. shown by embrittlement detector tests to prevent cracking of test specimens. Nearly all plants adopted nitrate treatment, and their caustic-cracking trouble did not recur. This method provides inexpensive and effective protection of boilers with welded drums; many boilers with welded drums are also treated with nitrate to protect rolled tube ends. Caustic cracking in boilers is no longer serious problem in US.—*CA*

Steam and Power Expansion—Shell Oil Company's Houston Refinery. C. A. SCHAEFFER. Southern Power & Ind., 71:8: 44 ('53). New boiler plant operating at 650 psi and 750°F final temp. is described. This plant is operated on 100% treated makeup. Untreated water is supplied by deep wells that discharge directly into deionization plant. Chem. compn. of water is practically const. and can be classified as high bicarbonate alky., low hardness, high total dissolved solids, and fairly high silica. First stage in treating process consists of

(*Continued on page 70*)

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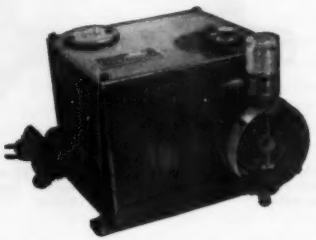

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cation removal in bank of 4 rubber-lined, 10-ft diam., 15-ft high exchangers filled with Zeo-Karb, sulfonated coal. Each exchanger has total treating capacity of 278,000 gal. Effluent is free from cations but contains CO_2, HCl, and H_2SO_4. This effluent is freed from CO_2 in redwood tower countercurrent to air current. Water is then passed through 4 exchangers, each 10-ft diam., 8 ft high, rubber lined, with treating capacity of 400,000 gal each. These exchangers contain Permutit S to remove anions and silica. Effluent is slightly alk. and passes to spray type deaerating feedwater heater, after which phosphate and Na_2SO_3 are added as precaution against scale and corrosion. Metering of water is used to control exchanger treating and regenerating periods, giving warning so that operator can initiate automatic regeneration cycle.—*CA*

Cooling-Water Problems in the New York Metropolitan Area. S. SUSSMAN. Ind. Eng. Chem., **44**:1740 ('52). In N.Y. metropolitan area, combination of soft, low-alky. makeup water and heavy atm. contamination reduces scaling to negligible problem and creates unusually severe corrosion problems. CO_2 and SO_2 scrubbed from air by recirculating water often reduce pH of untreated circulating cooling waters to 3.5 and below. Water treatment with alkali for pH control and chromates for passivating film formation gives most effective corrosion control. Sometimes silicates have been nearly as effective as chromates. Corrosion control treatment of water can be largely counteracted by poorly designed equipment or poor maintenance. Solid contaminants in water also provide operating problem. Other problems encountered in cooling systems are discussed.—*CA*

Survey of Water Desalting Investigations, in Particular the Electrodialytic Method. Y. B. NIEVELD & D. PAULI. Central Natl. Council for Applied Scientific Research, Netherlands, T.N.O., Rpt. T.A. 270 ('52). Different methods of desalting sea water and brackish water are described briefly, including distillation, freezing, ion exchange, and electrolysis. Literature on desalting of brackish water by electrodialysis is reviewed and discussed, and account is given of experimental work carried out in Netherlands on electrodialysis. In experiments with 3-compartment cell using nonselective or only slightly selective membranes of untreated cellophane or cellophane treated with lacquer, considerable corrosion of untreated anodic membrane occurred. Factors affecting corrosion of membrane were investigated, and methods of reducing it are suggested, including aerating anolytic solution to remove chlorine gas rapidly and treating membrane with bakelite; but, no matter what treatment is used, anodic membrane has limited life. Removal of chloride from dialysate was retarded if neutral rinsing liquids were used or if excess concentrations of acid or alkali were allowed to collect in anolyte or catholyte. With nonselective membranes, amount of sodium chloride removed per 100 amp-hr decreased as concentration of sodium chloride in solution decreased. It was concluded that use of nonselective membranes would be uneconomical on industrial basis because of high consumption of energy. Further experiments were therefore made using different types of selective membranes. Unless solution was continuously agitated, amount of sodium chloride removed decreased as current density increased, probably as result of formation of thin films of differing concentrations of sodium chloride close to membrane. In contrast to results obtained when nonselective membranes were used, neutral rinsing liquids gave best results. With selective membranes, it was possible to increase amount of sodium chloride removed per 100 amp-hr to 82% of theoretical maximum. To reduce concentration of chloride from 28 milliequiv. to 8 milliequiv./l, energy consumption of 3 kwhr/cu m was required. There was considerably less diffusion of sodium chloride through selective membrane than through nonselective membrane. Some preliminary experiments were made on desalting of water in 2-compartment cell with either nonreversible electrodes or with reversible silver–silver chloride electrodes. It appeared that 2-compartment cell with nonreversible electrodes for desalting water with high concentrations of chloride would be justified for industrial purposes; further studies are necessary on this subject. Silver–silver chloride electrodes would probably not stand up to regular use and their cost would make process uneconomical. As result of experiments it is suggested that desalting of brackish water could best be carried out in multicompartment apparatus with selective

(Continued on page 72)

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(*Continued from page 70*)

membranes and magnetite anodes, and cost of such treatment is estimated. Bibliography of 99 references is given, and results of experiments are shown in tables and graphs. —*WPA*

Scale Formation in Sea Water Distilling Plants and Its Prevention. H. HILLIER. Proc. Inst. Mech. Engrs. (Br.), **1B**:7:295 ('52). Scales found in sea water evaporators are formed of calcium sulfate, calcium carbonate, and magnesium hydroxide. Calcium sulfate scale can be avoided by using sufficiently dilute brine concentration to maintain sulfate in solution. Conditions are indicated under which formation of this scale can be avoided. Calcium carbonate and magnesium hydroxide scales are shown to be due to carbonate alkalinity in sea water, which is limited and reasonably constant. These scales are due to breakup of bicarbonate ions in sea water as heating and boiling occur. Up to well defined range of operating temperatures, scale that is predominantly of calcium carbonate is experienced. At higher temperatures, scale predominantly of magnesium hydroxide is formed; but both types of scale may occur in vicinity of changeover zone. Breakup of bicarbonate ions produces carbonate ions, which give rise to calcium carbonate scale. With further heating and boiling, breakup of carbonate ions occurs, with formation of hydroxyl ions, which combine with magnesium ions to form magnesium hydroxide scale. Some alkalinity leaves evaporator with blowdown, as calcium carbonate in solution, or calcium carbonate and magnesium hydroxide in suspension. Amount of scale formed is found to be proportional to amount of sea water used, and no benefit is obtained by operating at low brine densities. Rate of scale formation is greater for low than for high temperatures and increases with temperature difference across heating surface. Tests show that use of organic dispersive compounds gives rise to weaker scale structure, which allows some scale to

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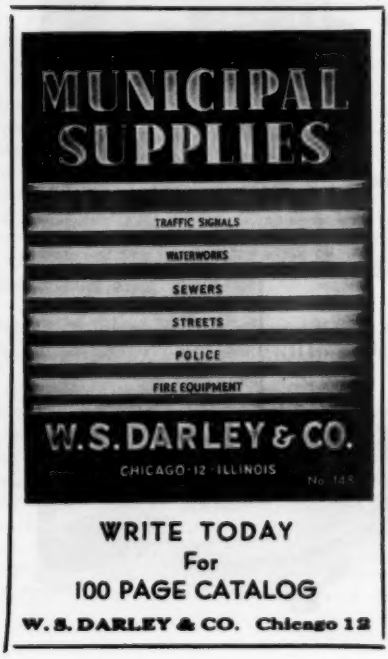

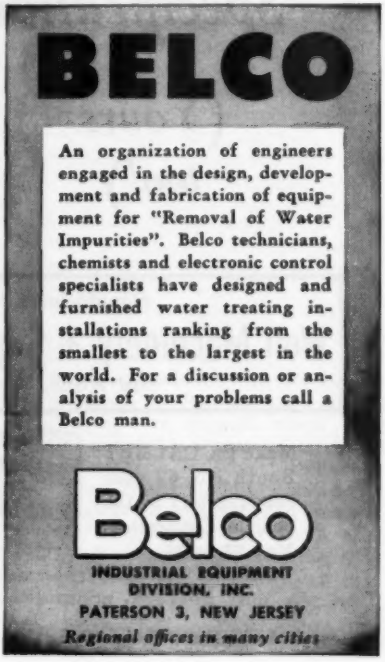
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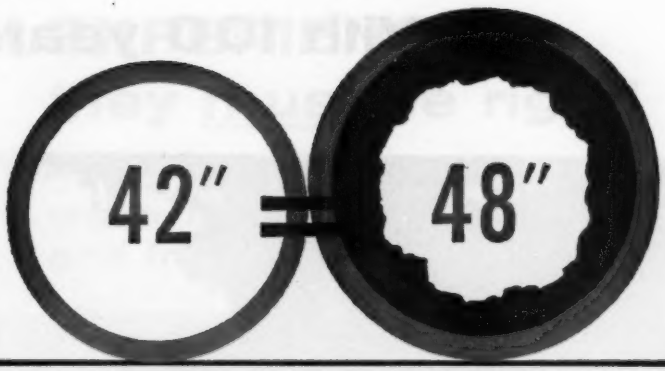

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(*Continued from page 72*)

be shed by cracking. Calcium carbonate and magnesium hydroxide scales can be completely prevented if appropriate quantity of hydrogen ions is supplied by injection of acids such as hydrochloric or sulfuric, or acid salt such as sodium bisulfate. These scales can also be prevented by injection of ferric chloride, which provides supply of ferric ions. Ferric ions combine preferentially with hydroxyl ions formed by breakup of bicarbonate and carbonate ions—thus allowing formation of ferric hydroxide, which is very insoluble and is maintained in suspension in brine without forming scale. Long-period tests on large commercial plants have confirmed research tests.—*Ed.*

The Ozonization of Water With Special Reference to Color Removal. A. T. PALIN. Wtr. & Wtr. Eng. (Br.), 57:271 ('53). Objects of investigation included determination of greatest degree of absorption of ozone capable of being effected in single application, to explore conditions governing such absorption, and to relate ozone so consumed to work done on water as measured by drop in color. Fe and Mn interfere with color removal from peaty water. If water contains much Fe or Mn, it is possible for color after ozonation to be greater than that of untreated water. It became clear, during investigation, that Fe and Mn were not likely to appear in amounts sufficient to interfere seriously with color removal. In any practical scheme for applying ozonated air, considerable proportion of ozone will not enter into solution in water at all. Consistency in results was attained only after most careful attention had been paid to sampling. Proportion of ozone which dissolves tends to decrease as applied dose of ozone is increased. Results provide some indication of effect of water quality on rate of solution of ozone. Indications were that, when raw-water color is high, ozone consumption of approximately 2.5 ppm would be required. Waters of moderate color might require only 2 ppm, and it is likely that, for long periods, satisfactory results would be obtained for ozone consumption as low as 1.5 ppm. In any scheme for recovery of ozone by reapplication of ozonated air, after one or more applications, it becomes apparent that stage will soon be reached where it is far cheaper to prepare fresh ozone than to attempt further recovery of unused ozone. Efforts have been made to recover waste ozonated air and, after redrying, to pass it again through ozonator. When incoming air initially contains ozone of less than equilibrium value, time taken to reach equilibrium would be shortened and, consequently, reduction in size of ozonator could be made.—*H. E. Babbitt*

Flocculation Phenomena in Turbid-Water Clarification. W. F. LANGELIER, H. F. LUDWIG & R. G. LUDWIG. Proc. ASCE, Separate No. 118 ('52). From previous studies on flocculation in turbid water, it was concluded that, in rapid flocculation with alum, there are normally 2 distinct reactions, one involving partial destabilization of suspended particles by aluminum ions through ion exchange, and other involving formation of hydrous oxide gel by hydrolysis of coagulant which acts as binding agent. It is now suggested that latter reaction is of secondary importance and that, as exchange capacity of suspension increases above criti-

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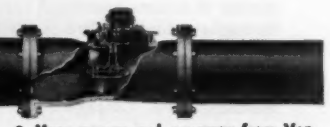

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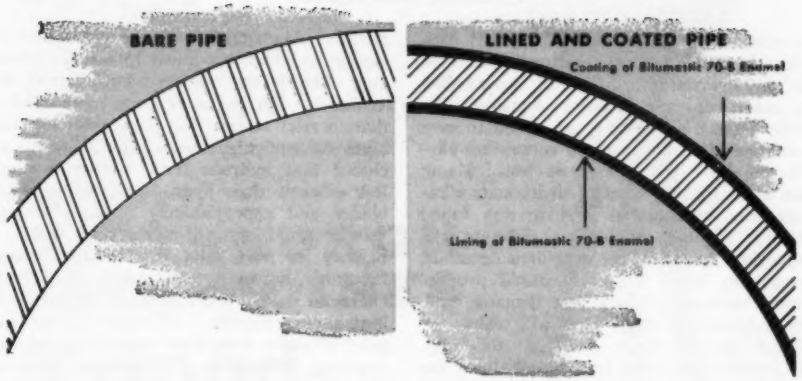

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(*Continued from page 76*)

cal value, rapid flocculation is achieved with chemicals which do not hydrolyze to form insoluble hydroxides. Series of experiments was made using turbid waters prepared artificially from 6 different types of soil to give turbidities of 45–63 ppm and containing particles of 1.4μ in diameter or less. Using alum as coagulant, effect of bicarbonate alkalinity was investigated, and it was found that, for efficient coagulation, different soil suspensions had different coagulant demands, increase in buffer capacity caused proportionate increase in coagulant demand, and, within limits of test, final pH value increased with increase in total alkalinity. For given suspension, optimum alkalinity for obtaining greatest reduction in turbidity with economic use of coagulant can be determined graphically. In waters of high alkalinity, it may be of advantage to neutralize part of alkalinity with acid before adding coagulant. For 6 synthetic suspensions used, optimum alkalinity varied from 0.5 to 0.8 milliequiv./l, and corresponding optimum pH values from 7.0 to 7.2. To determine effect of varying ratios of carbonate and bicarbonate alkalinity, different amounts of sodium or calcium hydroxide were added to suspensions buffered with sodium bicarbonate. For given total alkalinity, amount of coagulant required increased as ratio of carbonate to bicarbonate increased. In investigations on effects of sodium chloride and sodium sulfate on coagulation, it was observed that presence of sodium ions caused slight increase in amount of coagulant required, while range of effective coagulation was widened. Salts in concentrations greater than 400 ppm had dispersing effect on floc which was fine and slow settling. Typical sequestering or chelating agents, such as sodium metaphosphate or sodium versenate, increased amount of alum required for coagulation and caused deterioration in quality of floc produced. At concentrations of 5 ppm or more of metaphosphate, no floc formed; with concentrations of 170 ppm versenate, however, some flocculation could be achieved by increasing dose of alum. Anionic, cationic, and nonionic synthetic detergents were found to inhibit flocculation in varying degrees. Cationic detergents had greater inhibitory effect than other types. Efficiency of different hydrolyzing coagulants was compared, using alum, aluminum chloride, ferric chloride, ferric sulfate, lanthanum chloride, and thorium nitrate. Alum and aluminum chloride were similar in effect, but about 15% more aluminum chloride was required for effective coagulation. Ferric chloride was more efficient than ferric sulfate but less efficient than alum on equivalent basis, and it was concluded that hydrous ferric binder is much less efficient than hydrous aluminum oxide binder and approximately 3 times amount was required under conditions of test; efficiency of iron salts may compare more favorably, however, with waters of different character. Poor results were obtained with lanthanum chloride. Thorium nitrate was most effective coagulant tested, but amount required was about 3.7 times as great as that of alum. Size of particles causing turbidity is important factor in coagulation. When suspension contained only particles up to 1μ in diameter, good but slow-settling floc was obtained no matter what degree of turbidity. When, however, suspension contained coarser particles (up to 60μ), good flocs could not be obtained. For effective flocculation, water should contain particles both greater and smaller than 1μ in diameter. If water is deficient in either fine or coarse particles, they should be added before coagulation. Results of experiments are given in tables and graphs, and theories of various effects are discussed.—*WPA*

DISINFECTION

Iodine as a Bactericide. C. W. CHAMBERS ET AL. Soap, **28**:10:149 ('52). This paper by members of USPHS describes elaborate and carefully controlled study of bactericidal action of iodine, object of which was to determine suitability of iodine for disinfecting water. Authors express no conclusions on relative merits of iodine and chlorine, contenting themselves with stating concentrations of iodine required to disinfect under conditions used. No comparative tests with chlorine were made. 13 species of bacteria were used, all intestinal, and all Gram-negative bacilli except *Str. faecalis*. Dilute suspensions of these were added to large volumes of specially prepared water buffered to given pH in specially cleaned flasks (so prepared in order to eliminate any organic matter which would combine with iodine) containing various concentrations of iodine. After 1, 2, and 5 min aliquots were removed and mixed with sodium thiosulfate solution,

(*Continued on page 80*)

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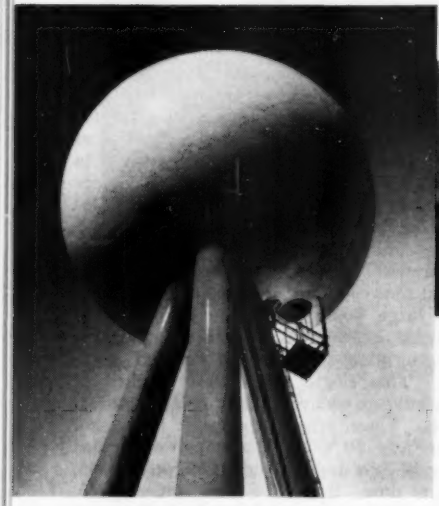
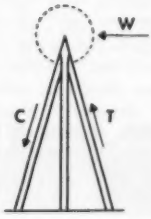


The TRIPOD-SPHERE illustrated, located at Gonzales, California, has 100,000-gallon capacity, with 31 ft sphere, on a 100 ft tower. Head range is 23 ft 1 in. Diagram shows how wind force (W) on sphere places columns in tension or compression, without bending.



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(*Continued from page 78*)

and survivors were enumerated in plates. Experiments were done at 2 temperatures, 2°–5° and 20°–26°C, and at 4 pH levels, 6.5, 7.5, 8.5, and 9.15 (iodine is less active in alkaline than in acid solution, but difference within this range was sometimes small). Every possible control appears to have been used (except, as already stated, one of sensitivity of culture to another disinfectant). Detailed results are given in table. There was some variation in species susceptibility, *S. typhi* being most and *Sh. sonnei* least susceptible. General significance of results is expressed by saying that min. concentration killing all species in 1 min under most favorable conditions (lowest pH and higher temperature) was 0.6 ppm; under least favorable, it was 4.3 ppm.—*BH*

Investigations of the Efficiency of Disinfection of an Ozonating Apparatus "System Blatter." W. KNAPP. Arch. Hyg. u. Bakt., **136**:426 ('52). Account of some preliminary experiments on value of new ozonating app. for sterilization of water. Details of app. are not given but it is stated that there is no necessity to cool or remove dust from incoming air, nor is any cooling of plant required. Experiments showed that this app. gave good results with raw spring water but was not satisfactory when same water was treated after being artificially polluted with bacteria and organic matter. Further investigation is needed to determine conditions under which app. may perhaps give good results with highly polluted waters.—*BH*

Preliminary Investigations With a "Sterilit" Experimental Filter Used for Drinking-Water Disinfection. J. F. BRAUNE. Gesundh.-Ing., **74**:12 ('53). "Sterilit" is 0.3–1.0-mm filtering material contg. Ag. Tap water of given compn. in contact with material for 4 min contained 7 γ Ag/l and removed 2.5×10^4 *Esch. coli*/l, artificially inoculated, in 2.5–3 hr. Bactericidal effectiveness of Sterilit-treated water decreased with increased amts. of org. matter, and on diln. of treated water with infected water. In dilns. greater than 1:2, resp., bactericidal effect was insufficient. Sterilit does not impart taste or odor to water.—*CA*

The Oligodynamic Action of Silver. W. ZIMMERMANN. Z. Hyg. u. Infektionskr., **135**:403, 414 ('52). I. *Mode of action.* Records some of main facts about oligodynamic action of metals, which was first observed and studied scientifically by Nageli, although his work was not published until after his death in 1893. Reference is made to use of copper and silver many centuries ago; for example, King Cyrus in his campaigns carried with him water from river Choaspes, stored in silver jugs. Description based on many published papers is then given of ionization of silver and silver compounds and of conditions under which suppression of ionization occurs through such factors as formation of silver colloids, silver complexes, and adsorption of silver ions. Silver ions which are positively charged are adsorbed on negatively charged surface of bacterial body—this is possible mechanism of oligodynamic action whic hinhibits bacterial multiplication. Some workers have found that lower limit of effective concentration of silver ions against bacteria lies between 2.0 and 3.0 μg/l of silver. Variable resistance of different organisms to this oligodynamic action of silver has been studied by many authors, and it is also found that some organisms can develop silver fastness by serial cultivation in media containing increasing amounts of silver. II. *Experiences with continued use of silver for purification of rural water supplies.* Use of silver preparation for sterilizing water in small country reservoir is described. Preparation used was silver chloride–sodium chloride complex ("Micropur") containing 1.0% silver. Initial large dose of 800 g of this preparation was added to reservoir, which at that time contained about 60 cu m of water. This large dose is recommended for first treatment in order to provide enough silver for adsorption on walls and floor of reservoir. This single shock dose resulted in disappearance of living *Esch. coli* for several weeks. Later, when experiment finally got under way 50 g of Micropur were added every 10 days and then dose was varied from time to time. Effects of treatment on *Esch. coli* and total count are described, discussed, and recorded in charts. Satisfactory results are claimed with maintenance of concentration of 2–3 μg/l of silver. Treatment has continued for more than year, and it is stressed that possible development of silver fastness should be reckoned with. Although more expensive than chlorination, silver treatment is claimed to have advantages of long continued efficiency between dosages and not to alter taste, smell, and appearance of water.—*BH*

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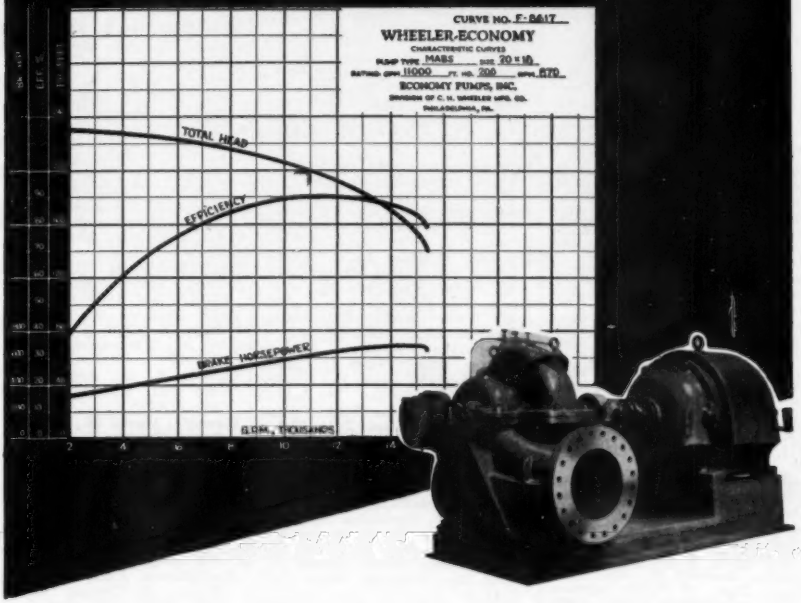

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Abbott, Marion J., Asst. Operator, North East Water Plant, Water Div., Dept. of Utilities, Houston, Tex. (Jan. '54) *M*

Affleck, Boyd C., Civ. Engr. & Land Surveyor, 218 Gore St., Nelson, B.C. (Jan. '54) *R*

Atchison, Thomas J., Water Plant Operator, Fort Sheridan, Ill. (Jan. '54) *MP*

Baird, Charles J., Water Plant Operator, Bldg. 29, Fort Sheridan, Ill. (Jan. '54) *P*

Barnwell, James M., Sales Repr., Johns-Manville Sales Corp., Box 421, Nashville, Tenn. (Jan. '54) *D*

Barr, F. E., Maj., Maintenance Div., Army Headquarters, Ottawa, Ont. (Jan. '54)

Benton, George E., Supt. of Works, Prince Rupert, B.C. (Jan. '54) *MRPD*

Billmire, Garrett O., Asst. Chief Engr., Dept. of Public Improvements, 810 Eversham Ave., Baltimore 12, Md. (Jan. '54)

Biros, John A., Asst. to Supt., Dept. of Water & Sewers, 28 Beekman Ave., N. Tarrytown, N.Y. (Jan. '54) *MD*

Blalock, John M., Mgr., General Chemical Div., Allied Chemical & Dye Corp., 1221 Locust, St. Louis 3, Mo. (Jan. '54) *P*

Blunden, Montague, Jr., Sales Engr., Permutit Co., 250 N. Water St., Decatur, Ill. (Jan. '54) *P*

Boisuert, Paul P., Town Engr., 900—6th Ave., Shawinigan Sud, Que. (Jan. '54)

Brown, E. W., Owner & Gen. Mgr., Brown Steel Contractors, Box 357, Newman, Ga. (Jan. '54)

Bulthuis, Herbert, Chemist, Board of Public Works, Holland, Mich. (Jan. '54) *P*

Butterbaugh, Lowell D., Culligan Soft Water Service of Eaton, 510 N. Cherry St., Eaton, Ohio (Jan. '54) *MRPD*

Butts, Herbert, Supt., Water Dept., Sherburne, N.Y. (Jan. '54) *MPD*

Carpenter, Le Roy V.; *see* Hawthorne (N.Y.) Improvement Dist.

Carr, James L., Water Purification Technician, 1210 Hemphill Ave., Atlanta, Ga. (Jan. '54) *P*

Carson, Dewey L.; *see* Desert Hot Springs (Calif.) County Water Dist.

Carson, Herbert F., Asst. Supt., Water Dept., 3102 Cedar, Everett, Wash. (Jan. '54) *MRP*

Cason, J. M., City Engr., City Hall, Bloomington, Ind. (Jan. '54)

Childers, Jim B., Chief Eng., Childers Eng. Co., 632 Wilson Bldg., Corpus Christi, Tex. (Jan. '54) *RP*

Coker, W. R.; *see* Shaw Air Force Base (S.C.)

Commerce Water & Light Com., J. L. McClure, Supt., Commerce, Ga. (Corp. M. Jan. '54) *MP*

Cornelia, City of, Pope Ellard, City Mgr., Cornelia, Ga. (Munic. Sv. Sub. Jan. '54) *P*

Crusselle, Guy M., Supt. Water Dept., Carrollton, Ga. (Jan. '54) *M*

Dandridge, John W., Civ. Engr., 212½ N. Independence Blvd., Charlotte, N.C. (Jan. '54) *RPD*

Darling, William A., W. A. Darling & Assocs., 414 Transfer Bldg., Ft. Wayne, Ind. (Jan. '54) *PD*

Dean, Lewellyn D., Proj. Engr. of Water Works Construction, Jackson, Miss. (Jan. '54) *MD*

Desert Hot Springs County Water Dist., Dewey L. Carson, Mgr., Box 164, Desert Hot Springs, Calif. (Corp. M. Jan. '54) *MRPD*

Douglass, B. A., Supt., Water Works Board, Box 287, Mulga, Ala. (Jan. '54) *M*

Ellard, Pope; *see* Cornelia (Ga.)

Engelbrecht, Richard S., Graduate Student, Dept. of Civ. & San. Eng., Massachusetts Institute of Technology, Cambridge 39, Mass. (Jr. M. Jan. '54) *P*

Erickson, Arthur E., Tech. Director, Weyerhaeuser Timber Co., Pulp Div., Longview, Wash. (Jan. '54) *P*

Fassnacht, R. S., City Chemist, Salina, Kan. (Jan. '54) *P*

Fitzgerald, Robert J., Dist. Mgr., Electro Rust-Proofing Corp., Belleville, N.J. (Jan. '54) *PD*

Folsom, Amer C., Dist. Sales Mgr., Mathieson Chemical Corp., Mathieson Bldg., Baltimore 3, Md. (Jan. '54) *P*

Forero Velez, Jorge, Ing. Civ. de la U.N. de Colombia, Ave. 33, No. 16–66, Bogota, Colombia (Jan. '54)

Foster, John H., Engr., Malcolm Pirnie Engrs., 25 W. 43rd St., New York, N.Y. (Jan. '54) *RPD*

Foster, M. E., M. E. Foster Co., 1308 Home Ave., Kokomo, Ind. (Jan. '54) *D*

Frey, Carl W., Chief, Customer Service Sec., Water Dept., Rm. 1024 City Hall Annex, Juniper & Filbert Sts., Philadelphia 7, Pa. (Jan. '54) *M*

Funk, Francis F., City Engr., Fredericksburg, Va. (Jan. '54) *MPD*

Gelperin, Abraham, Director of Public Health, Des Moines–Polk County Health Depts., City Hall, Des Moines, Iowa (Jan. '54) *RP*

Girk, Donald M., Supt., Water Dept., Penfield, N.Y. (Jan. '54) *MP*

Glass, Curtis A., Supt., Munic. Light & Water, 524½—5th St., Pawnee, Okla. (Jan. '54) *MRPD*

Goodwin, John H., Asst. Dist. Mgr., Johns-Manville Sales Corp., 116 New Montgomery, San Francisco 5, Calif. (Jan. '54) *M*

Grant, Meredith, Sales Repr., Wallace & Tiernan Co., Inc., Box 294, Skaneateles, N.Y. (Jan. '54) *P*

Gustafson, Carl J., Gen. Foreman, 353—9th Ave. W., Prince Rupert, B.C. (Jan. '54) *MRPD*

Haun, Allison J., Sales Repr., Johns-Manville Sales Corp., 430—40th St., Oakland 9, Calif. (Jan. '54) *M*

Hawthorne Improvement Dist., Le Roy V. Carpenter, Supt., 152 Brady Ave., Hawthorne, N.Y. (Munic. Sv. Sub. Jan. '54)

Heald, H. Elwood, Salesman, American Cyanamid Co., Miller Rd., Kalamazoo, Mich. (Jan. '54) *P*

Hill, Lester M., Supt. & Secy.-Treas., Sturgis Water Works Co., Sturgis, S.D. (Jan. '54)

Holz, Robert F., Sales Repr., James B. Clow & Sons, 210 S. 5th St., Minneapolis, Minn. (Jan. '54) *M*

Howell, L. M., Asst. City Engr., City Hall, Meridian, Miss. (Jan. '54) *MRPD*

Howells, David H., Sr. Asst. San. Engr., Region V, U.S. Public Health Service, 69 W. Washington St., Chicago 2, Ill. (Jan. '54) *RP*

Huddleston, Ira M., City Engr., City Hall, Coquille, Ore. (Jan. '54) *MRPD*

Hule, Robert W., Supt., Water & Sewer Systems, Box 6, Murray, Ken. (Jan. '54) *MD*

Hutchinson, John P., Dist. Engr., Wallace & Tiernan, Inc., Dist. Office, 1328 N.W. 23rd St., Oklahoma City, Okla. (Jan. '54) *MRP*

Irvine, Thomas M.; *see* Abbotsford (B.C.)

Johnson, Albert S., Jr., Supt., Water Dept., Hartwell, Ga. (Jan. '54) *MRPD*

Johnson, Maurice B., Salesman, Consumers Public Power Dist., Columbus, Neb. (Jan. '54)

Kelley, Ira C., Water Purif. Technician, Water Dept., 1210 Hemphill Ave., N.W., Atlanta, Ga. (Jan. '54) *P*

Krahmer, Anthony, Plant Mgr., Schwartz Co., Inc., 1600 E. 11th St., Box 1702, El Paso, Tex. (Jan. '54) *P*

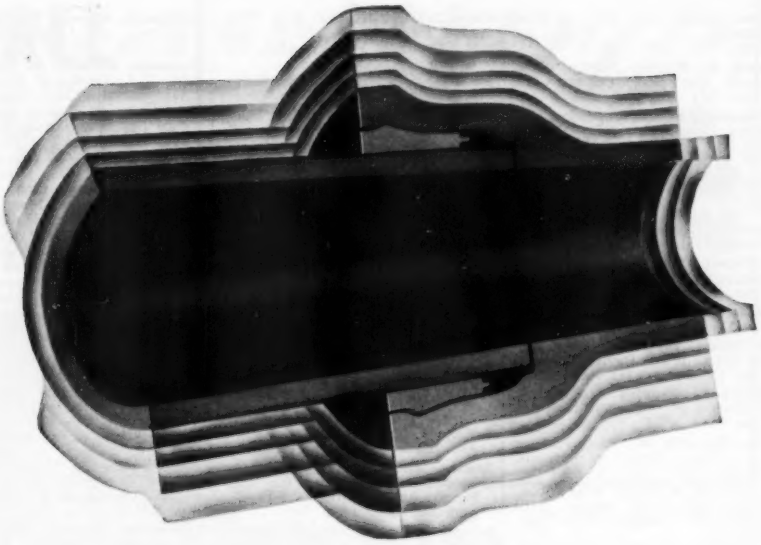
Lake, George W. C., Munic. Engr., Eng. Dept., Richmond Town Hall, Lulu Island, Vancouver 4, B.C. (Jan. '54) *D*

Lancaster, Gerald D., Chief Chemist, Brooks Chemicals, Inc., 3304 E. 87th St., Cleveland, Ohio (Jan. '54) *P*

Lemmon, Richard H., Sales Repr., Lynchburg Foundry Co., Lynchburg, Va. (Jan. '54)

Lovelace, Richard E., Foreman, Water Treatment Plants, Power Dept., Remington Arms Co., Lake City Arsenal, Independence, Mo. (Jan. '54) *P*

(Continued on page 84 P&R)



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Luker, James F., Mgr., Andrews Chemical Co., 420 Broad St., Utica, N.Y. (Jan. '54) *P*

Lynch, K. P., Mgr., Water Works Board, Box 1029, Opelika, Ala. (Jan. '54) *MRPD*

Mackenzie, W. B., Supervisor, Asbestos Pipe Dept., Atlas Asbestos Co., 224 Davenport Rd., Toronto, Ont. (Jan. '54)

Manning, James D., Aqua Pura Chlorinating Co., 17138 Oak Dr., Detroit 21, Mich. (Jan. '54) *PD*

Manning, Percy C., City Engr., Franklinton, La. (Jan. '54) *P*

Mathisson, Roy W., Supt. of Accounts, Utilities Board, Knoxville, Tenn. (Jan. '54)

McClure, J. L.; *see* Commerce (Ga.) Water & Light Com.

McElhiney, Wilda A., Chief Billing Clerk, Water Dept., Oklahoma City, Oklahoma (Jan. '54) *M*

McKinney, Charles S., Mgr. of Utilities, Ft. Lauderdale, Fla. (Jan. '54) *MRP*

Mees, Quentin M., Asst. Prof. of Civ. Eng., Univ. of Arizona, Tucson, Ariz. (Jan. '54) *RP*

Michael, S. A., Cons. Engr., Kirkham, Michael & Assocs., 1504 Dodge St., Omaha, Neb. (Jan. '54) *PD*

Milledgeville State Hospital, Roger W. Stembridge, Milledgeville, Ga. (Corp. M. Jan. '54) *MPD*

Miller, David R., Project Mgr., Daniel, Mann, Johnson & Mendenhall, 4201 Sunset Blvd., Los Angeles 29, Calif. (Jan. '54) *D*

Norman, William L., Mgr., Munic. & Eng. Dept., Gordon & Belyea Ltd., 101 Powell St., Vancouver 4, B.C. (Jan. '54)

O'Dowd, Dennis P., Comr. of Public Works, 919 Cornelia St., Utica, N.Y. (Jan. '54) *M*

Padgen, Matt, Supt., Water Works, McCook, Ill. (Jan. '54) *M*

Parnell, Leonard C., Sales Engr., Asst. Branch Mgr., American Cast Iron Pipe Co., 1043 Plymouth Bldg., Minneapolis, Minn. (Jan. '54) *PD*

Patel, B. D., Gujarat Cement Pipe Co., Machiketa, Ahmedabad 8, Maninagar, India (Jan. '54)

Pope, Robert M., San. Engr., Malcolm Pirnie Engrs., 25 W. 43rd St., New York 36, N.Y. (Jan. '54) *RPD*

Rhodes, T. L., Supt., Water Works, McRae, Ga. (Jan. '54) *D*

Riggins, Wallace R., Asst. Supt., Water & Light Plant, Easley, S.C. (Jan. '54) *MRP*

Roberts, Dan T., Salesman, Schwartz Co., Inc., Box 4218, West End Station, Corpus Christi, Tex. (Jan. '54) *P*

Rock Rapids, Utilities Div., Water Dept., Max V. Wellington, Supt. of Distr., 310 S. 3rd Ave., Rock Rapids, Iowa (Corp. M. Jan. '54) *MR*

Rooney, Bernard J., Sales Engr., Rockwell Mfg. Co., 7701 Empire State Bldg., New York 1, N.Y. (Jan. '54)

Roval, Julio J., Gen. Mgr., Water System, Box 457, Rio Dell, Calif. (Jan. '54) *M*

Samer, Carl, Salesman, Johns-Manville Sales Corp., 604 Central Ave., East Orange, N.J. (Jan. '54)

Santos, John F., Chemist, Water Resources Investigations, U.S. Geological Survey, 810 N. 29th St., Corvallis, Ore. (Jan. '54) *R*

Schatz, Henry C., Jr., Sales Engr., T. C. Heyward, 518 E. Morehead St., Charlotte, N.C. (Jan. '54) *P*

Schwartz, G. E., Vice Pres., Schwartz Co., Inc., 1600 E. 11th St., Box 1702, El Paso, Tex. (Jan. '54) *P*

Schwartz, J. D., Pres., Schwartz Co., Inc., 1600 E. 11th St., Box 1702, El Paso, Tex. (Jan. '54) *P*

Seckman, Harold E., Developmental Chemist, Silas Mason Co., Iowa Ordnance Plant, Box 561, Burlington, Iowa (Jan. '54) *P*

Shaw Air Force Base, W. R. Coker, Operations Foreman, Water & Sewage, Shaw Air Force Base, S.C. (Corp. M. Jan. '54)

Slaughter, J. M., Jr., City Engr., City Hall, Meridian, Miss. (Jan. '54) *MRPD*

Srack, Leland M., City Mgr. & Supt. of Water Dept., City Hall, Salina, Kan. (Jan. '54) *MRPD*

Stembridge, Roger W.; *see* Milledgeville (Ga.) State Hospital

Stineback, George F., Supt., Water Dept., 205 S. Shield St., Knox, Ind. (Jan. '54) *M*

Swenson, Herbert A., Dist. Chemist, U.S. Geological Survey, Box 411, Corvallis, Ore. (Jan. '54) *R*

Swift, George D., Councilman, City Hall, Cedar River Park, Renton, Wash. (Jan. '54) *D*

Swingle, Harold R., Service Engr., Ingersoll-Rand Co., 526—1st Ave. S., Seattle, Wash. (Jan. '54)

Swob, Ray, Water Plant Operator, Piqua, Ohio (Jan. '54) *MP*

Symons, James M., Student, Civ. & San. Eng., Cornell Univ., Ithaca, N.Y. (Jr. M. Jan. '54) *MP*

Tanner, Frank M., Operator, Water Treatment Plant, Adolph Coors Co., Golden, Colo. (Jan. '54) *P*

Thaeder, Frank R., Sales Engr., Layne-New York Co., 92 Liberty St., New York, N.Y. (Jan. '54) *RP*

Tinsley, R. A., Asst. Supt., Water & Light Plant, Box 214, Easley, S.C. (Jan. '54) *MPD*

Turney, W. F., & Assocs., William F. Turney, 223 Montezuma Ave., Santa Fe, N.M. (Corp. M. Jan. '54) *MRPD*

Turney, William F.; *see* Turney, W. F., & Assocs.

Utermark, Henry, Supt., Water Dept., 2020 Chestnut, Homewood, Ill. (Jan. '54) *M*

Vallen, Ernest E., Chief Clerk, Bureau of Water Works, Portland, Ore. (Jan. '54) *M*

Van Den Berg, Cornelius, Vice Chairman of Board of Directors, Southern Natural Gas Co., Watts Bldg., Birmingham, Ala. (Jan. '54)

Wellington, Max V.; *see* Rock Rapids (Iowa)

Werner, Paul L., Water Distr. Supt., Corpus Christi, Tex. (Jan. '54) *MRP*

Widmer, Kemble, Prin. Geologist, Bureau of Geology & Topography, 520 E. State St., Trenton, N.J. (Jan. '54) *R*

Winamac Munic. Light & Water Works, C. E. Zellers, Supt., Winamac, Ind. (Munic. Sv. Sub. Jan. '54)

Woodward, T. E. P., Engr., M. G. Aldridge Construction Co., Macon, Ga. (Jan. '54) *D*

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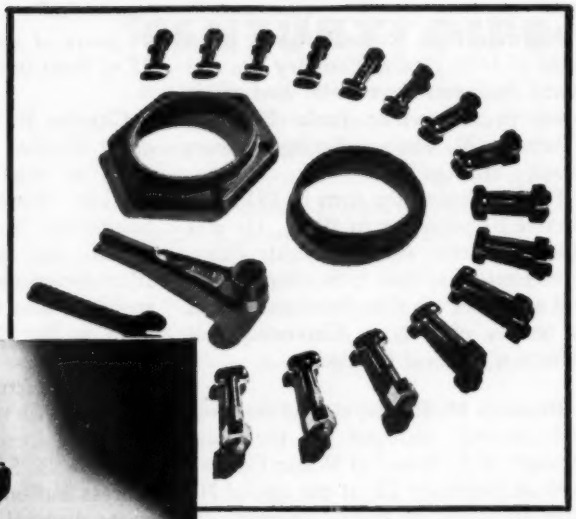
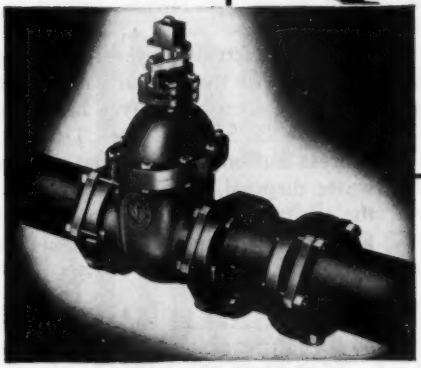




IS: A RATCHET AND OPEN END WRENCH, THREE RUBBER GASKETS, THREE CAST IRON FOLLOWER RINGS AND A HAND FULL OF BOLTS AND NUTS ***TO INSTALL***

the New SMITH CUT IN VALVE & SLEEVE

Gone are the days of—large costly excavations—melting furnaces and pouring pots—pouring and caulking lead joints—when the New All Mechanical Joint Smith Cut In Valve and Sleeve is used.

The Cut In Valve can be installed rapidly, in fair or stormy weather on Cast Iron A.W.W.A. and Federal specification water mains, by unskilled labor, using only two wrenches.

Moulded rubber gaskets fit into machined "Stuffing Box" type joints, guaranteeing a permanent leak-proof seal.

Smith Cut In Valves are manufactured in compliance with the A.W.W.A. Gate Valve specification, and all parts are interchangeable with like parts of Smith A.W.W.A. Gate Valves.

Write for Bulletin No. MJ2.

37

THE A.P. SMITH MFG. CO.

EAST ORANGE, NEW JERSEY

(*Continued from page 46 P&R*)

Norman F. S. Russell, former president of U.S. Pipe & Foundry Co. and board chairman since 1948, died at his home in Edgewater Park, N.J., on February 24, after suffering a heart attack. He was 74.

He had joined the firm in 1910 and became its president in 1923. He was also a director of the Colgate-Palmolive-Peet Co., the U.S. Sugar Co., and a number of other firms, and served as trustee of Colgate University and Jefferson Medical College.

Roswell M. Roper, retired engineer and general manager of the East Orange, N.J., Board of Water Comrs., died on February 22, at the age of 70, after an illness of several months. A former chairman of the New Jersey Section and recipient of its Fuller Award, he had retired in 1952 after 44 years of service to his community, 35 of them in the capacity of engineer.

Charles R. Cox, an AWWA Honorary Member and prominent for many years as chief of the Water Supply Section, Bureau of Environmental Sanitation, New York State Dept. of Health, has joined the Institute of Inter-American Affairs as a sanitary engineer, and has received an assignment to Rio de Janeiro, Brazil.

F. W. Kittrell, formerly a sanitary engineer with the Atomic Energy Commission's Isotopes Div., has joined Frederic B. Stevens, Inc., Detroit, as process and sales engineer on industrial waste disposal. He will specialize in the sanitary engineering aspects of the firm's new plating waste disposal equipment and supply line.

(*Continued on page 88 P&R*)

Depend on Cyanamid's

ALUM

for 6 good reasons

1. It feeds uniformly, without trouble, in solid or liquid form.
2. It has a wide pH range for effective coagulation.
3. It forms floc rapidly.
4. It gives maximum adsorption of suspended and colloidal impurities.
5. It causes minimum corrosion of feeding equipment.
6. It is available in granular form or in the new easy-to-use liquid form.

Write for complete information on Cyanamid's ALUM (Commercial Aluminum Sulfate). Make your next order Cyanamid's ALUM.

AMERICAN Cyanamid COMPANY

Heavy Chemicals Department
30 Rockefeller Plaza, New York 20, N. Y.

In Canada: North American Cyanamid Limited, Toronto and Montreal

"CENTURY"® PIPE

is made from asbestos fiber and portland cement—two almost indestructible materials. Being non-metallic it *cannot* tuberculate. Through generations of service its bore stays clean and smooth. Friction remains at a minimum, pumping costs stay low.

Consider the many other distinct advantages of "Century" pipe and you'll see why more and more thrifty towns are choosing it—why it's the wise choice for your community, too!

Write for further information now.

non-tuberculating

QUALITIES THAT MAKE "CENTURY" PIPE ECONOMICAL, TROUBLE-FREE, LONG-LIVED

1. NON-TUBERCULATING
2. NON-CORROSIVE
3. EXCEPTIONALLY STRONG
4. DURABLE
5. IMMUNE TO ELECTROLYSIS
6. TIGHT JOINTS
7. SMOOTH BORE
8. EASILY, QUICKLY LAID
9. LIGHT WEIGHT
10. LOW COST

"Century" pipe meets the A.W.W.A., A.S.T.M. and Federal Specifications for asbestos-cement pressure pipe.

"Century" pipe awaiting installation along U. S. Route 1—part of an 8000 ft. water supply line, 12" Class 150 pipe, from the Borough of Media Water Works to Middletown Township, Pa.

See us at the A.W.W.A. Annual Convention, May 23-28, 1954 • Booths 5 and 6 • Civic Auditorium, Seattle, Wash.

KEASBEY & MATTISON COMPANY • AMBLER • PENNSYLVANIA

Nature made asbestos . . . Keasbey & Mattison has made it serve mankind since 1873

(*Continued from page 86 P&R*)

D.M. is for D.M. for what D.M. is doing for D.M., all of which involves Des Moines, Iowa, and its water superintendent, Dale Maffitt, in a very happy relationship. What called the situation to our attention was nothing so normal and to be expected as Dale's recent accession to the position of AWWA President-Elect, but the appearance of a lead editorial in the Des Moines *Tribune* featuring the fact that "long run water supply is not a serious worry to Des Moines." Not just the fact of that matter in these days of almost universal shortage, but its public appreciation are certainly worthy of note. Hard enough sometimes to get the press to sound the alarm when the well is running dry, but to have it devote its editorial columns to reminding readers that the city's sources of supply are stable and dependable, its reserves are adequate, and its water works board is doing an effective job of planning for the future is something almost out of this world. Of course, there aren't too many cities about which such things could be said if they would be said—such things as:

> The problem for the future is not likely to be one of supply. It will be one of providing facilities for transporting and purifying the water. The water works is in fine shape financially and, if present conditions continue, should be able to provide for the water needs of Des Moines without great difficulty. . . . As reserves dwindle in other areas, industries which depend on plentiful water supply should find Des Moines increasingly attractive as a site for industrial development.

D.M.phasis sure ain't deemphasis.

(*Continued on page 90 P&R*)

Glazed Fire Clay

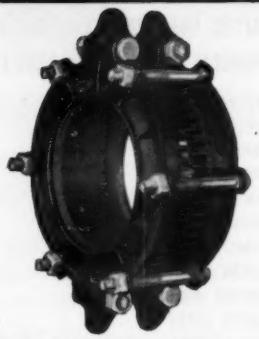
Tile Filter Bottoms

Successfully serving over 250 plants with a daily capacity of more than 1¼ billion gallons.

Permanent • No corrosion or tuberculation • Equal distribution • Uniform filtration • Low loss of head • Requires only small sized gravel • No metal in contact with water!

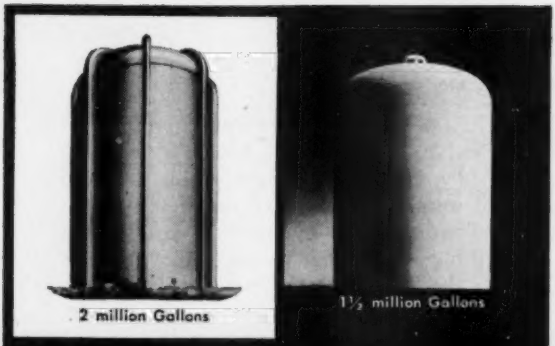
F. B. LEOPOLD CO., INC.
2413 W. Carson Street, Pittsburgh 4, Pa.

FOR REPAIRING BROKEN MAINS

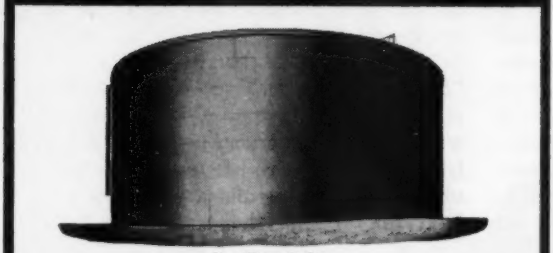


Skinner Seal Split Coupling Clamp. One man can install in 5 to 15 minutes. Gasket sealed by Monel band. Tested to 800 lbs. line pressure. A lasting repair. 2"-24" inclusive. Write today for new catalog.

M. B. SKINNER CO.
SOUTH BEND 21, INDIANA, U.S.A.



HAMMOND Standpipes . . . Designed to Harmonize with Surroundings.



HAMMOND Steel Reservoirs . . . . . Efficient and Economical

when located on ground sufficiently high to produce required gravity pressure—Illustrated is a Hammond five million Gallon Steel Reservoir.

HAMMOND WATER STORAGE TANKS

By the very nature of water supply service, storage tank integrity of design and soundness of construction are absolutely essential.

For more than half a century Hammond has been incorporating these characteristics in all its products — Steel Standpipes • Steel Reservoirs • Elevated Water Tanks • Water Spheres • Filtration and Purification Units for general water supply and fire protection systems.

Hammond Water Storing and Processing Vessels are built to all standard codes and specifications including those of the American Water Works Association, Associated Factory Mutual Fire Insurance Companies, the National Board of Fire Underwriters, the Factory Insurance Association.

HAMMOND Elevated Tanks . . . Double Ellipsoidal, Cone Roof, Radial Cone Bottom and Sphere . . . from 25,000 to 3,000,000 gallon capacity

Catalog H_2O details and describes all HAMMOND Water Storage and Processing Vessels . . . Write for your copy.

HAMMOND IRON WORKS

WARREN and BRISTOL, PA. • PROVO, UTAH • CASPER, WYO. • BIRMINGHAM, ALA.

Sales Offices: NEW YORK 20 • AKRON • BOSTON 10 • BUFFALO 2 • CHICAGO 3 • CINCINNATI 2 • CLEVELAND 15 • EL PASO • HOUSTON 2 • LOS ANGELES 14 • PITTSBURGH 19 RICHMOND 20 • SAN FRANCISCO • WASHINGTON 6, D.C. • HAVANA • "TIPSA" BUENOS AIRES

(Continued from page 88 P&R)

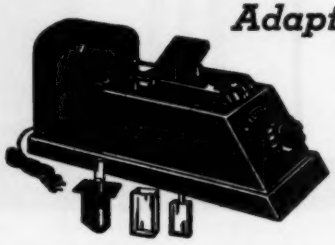
Weatherproofing for weatherbeaten weathermen has just been applied by the U.S. Court of Appeals in St. Louis in ruling that a group of disgruntled Missourians could not sue the weatherman for his mispredictions, regardless of the consequences suffered. We, who for long have been spelling them, "whethermen," certainly find nothing too surprising in their need for protection, but what does surprise us is the apparent surrender of traditional Missouri you've-got-to-show-meism inherent in the suit. As a matter of fact, with our ruggedest exponents of skepticism now resorting to the courts to protect themselves against their own gullibility, our missing meteorologists may find themselves more reprieved than relieved of their responsibility. Who knows, nowadays, when they'll be investigated?

A new lightweight tapping machine, the Model B, has been produced by Hays Mfg. Co. to drill, tap, and install ½- to 1-in. corporation stops in mains under full pressure. Use of a high strength aluminum alloy reduces the weight of the unit to 36 lb, thus making it easier to carry and operate.

A hardness test kit suitable for field use has been produced by Calgon, Inc., employing a simplification of the Schwarzenbach method. Known as "Speedy-Kit," it provides a quick check of water hardness that gives results in whole grains per gallon (17-ppm units). Containing only two bottles with measuring dropper caps and a glass vial to hold the sample, the pocket-size kit can be used to make from 50 to 100 hardness tests, depending on the amount of hardness present.

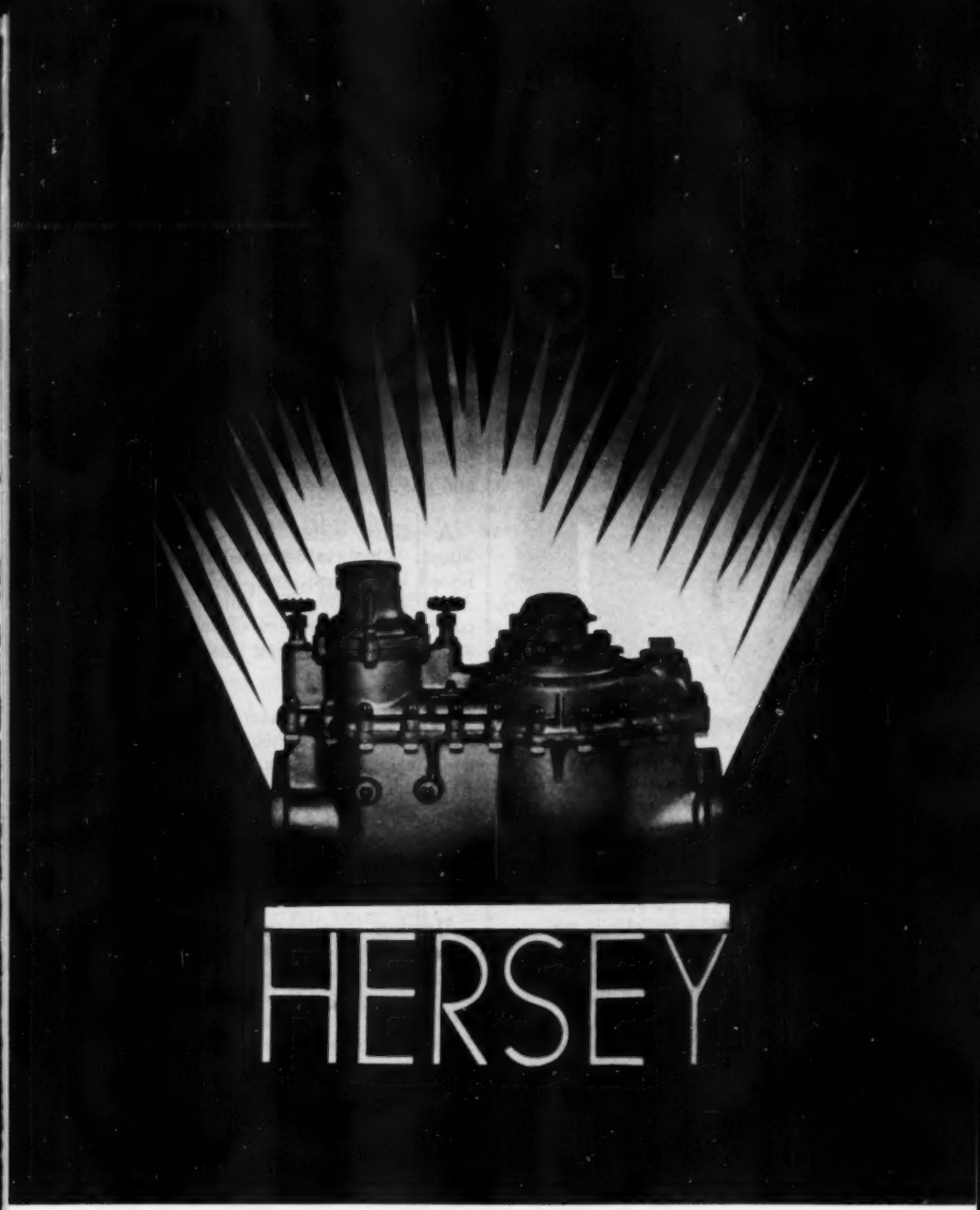
KLETT SUMMERSON
ELECTRIC PHOTOMETER

Adaptable for Use in Water Analysis



Can be used for any determination in which color or turbidity can be developed in proportion to substance to be determined

KLETT MANUFACTURING CO.
179 EAST 87th STREET • NEW YORK, N. Y.



It has been proven by many years of constant use that the

HERSEY COMPOUND METER

will deliver a more accurate registration of all rates of flow than any single unit or battery of meters. All bronze case from 2" to 6"

A Hersey Creation that has never been equaled

HERSEY MANUFACTURING COMPANY

SOUTH BOSTON, MASS.

BRANCH OFFICES: NEW YORK — PORTLAND, ORE. — PHILADELPHIA — ATLANTA — DALLAS — CHICAGO
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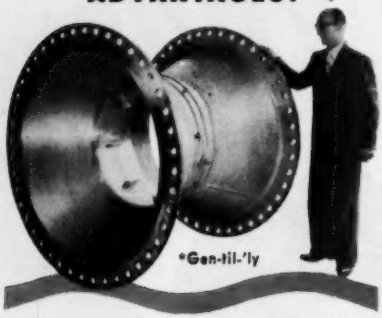
FOR
FLOW MEASUREMENT
only the Gentile*
FLOW TUBE
manufactured by
FOSTER
offers you all these
ADVANTAGES:



ACCURACY – Produces differential from points of equal cross-sectional area . . . furnished with head capacity curves, and guaranteed for exceptional accuracy when used with any standard indicating, recording or integrating meter.

LOW HEAD LOSS – Available in several types and D/d ratios to provide differentials that can be accurately measured with least head loss.

LOW INSTALLED COST – Average length is only 1½ times the pipe diameter, and straight runs entering and following are not required unless installed near throttling valves or regulators.

Write for Bulletin FT-101 or specific recommendations

75 YEARS OF EXPERIENCE

FOSTER ENGINEERING COMPANY

835 LEHIGH AVENUE UNION, N.J.

AUTOMATIC VALVES
SAFETY VALVES • FLOW TUBES

Service Lines

Chemical cleaning of condenser tubes is discussed in a paper reprinted from *Power Engineering* and distributed by Dowell Inc., Box 536, Tulsa 1, Okla. A leaflet on the removal of scale from water and gas lines is also available.

A utility water bath, the Blue M Magni Whirl, is described in a circular issued by Soiltest, Inc., 4522 W. North Ave., Chicago 39. The units, which offer controlled temperatures up to 100°C, are available in size ranging from 7½ by 12 in. to 18 by 36 in.

Liquid level measuring systems—a round dozen of them—are described and illustrated by Minneapolis-Honeywell Regulator Co., Wayne & Windrim Ave., Philadelphia 44, Pa., in a 24-page bulletin, No. 1160. A check list tabulation facilitates comparison of the different systems.

Heating pipelines, either to prevent freezing of exposed lines or to maintain temperatures necessary for special processes, by means of Calrod tubular heaters, is discussed in an 8-page booklet, GEA-5095A, distributed by General Electric Co., Schenectady 5, N. Y. Typical application examples, which give the necessary power input per unit of pipe surface, are given.

Diatomite filters, produced by the General Filter Co., 923—2nd St., Ames, Iowa, are described and illustrated in a 4-page folder available on request. In addition to conventional applications for swimming pools and similar service, the equipment may be used to remove oil from steam condensate.

(*Continued on page 93 P&R*)

AWWA

Membership Certificate

●

Designed to fit any standard 8- by 10-inch frame, this new version of the Association membership certificate will make a handsome addition to your office.

The document is tastefully printed on white rag paper, with the member's name hand-lettered.

When ordering your certificate, please be sure to print your name *exactly* as you wish it to appear, and enclose your check for $1.00 to cover the cost of lettering and production.

●

AMERICAN WATER WORKS ASSOCIATION

521 Fifth Ave., New York 17, N.Y.

(*Continued from page 92 P&R*)

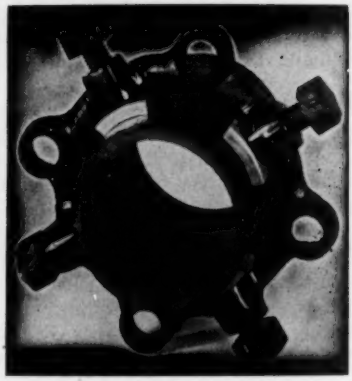
Water softening and demineralizing units are the subjects of two bulletins published by Hungerford & Terry, Inc., Clayton, N.J. Bulletin IS-1, on "Inversand Zeolite Water Softeners," contains 24 thoroughly illustrated pages of information about manual, semiautomatic, and fully automatic operation of these units, including photographs of actual installations. Bulletin DM, "Demineralizing Units," is an 8-page description of the various combinations and types of ion exchange available for either partial or total demineralization, including silica removal.

A single-stage steam turbine—the De Laval HCB—offering a maximum of 100 hp, is described in a 6-page folder available from De Laval Steam Turbine Co., Trenton 2, N.J. For those whose sensibilities have not been blunted by long poring over technical catalogs, it is worth noting that this folder, Bul. 4206, as well as a catalog of worm gear sets also issued by De Laval, won awards for readability and graphic appeal at the 12th annual exhibition of printing held by the New York Employing Printers Assn. in January.

Allis-Chalmers squirrel cage induction motors, which are in the process of being revised to conform to the NEMA standards adopted in November 1952, are the subject of three bulletins just issued by the company. A catalog on open motors is devoted to types G, AP, and APWW; one on totally enclosed, fan-cooled motors to types GZ and APZ; and one on explosion-proof motors to types GZZ and APZZ. Emphasizing that the new standards mean "equal horsepower in a smaller package," the company advises that the new motors are now available in frame sizes 182 and 184. Larger sizes will become available periodically until fall of 1955, when the changeover will be completed. Copies of the new catalogs may be obtained from Allis-Chalmers Mfg. Co., Milwaukee 1, Wis.

(*Continued on page 94 P&R*)

EASY TO SERVICE!
and assure
FULL REVENUE
That's How
AMERICAN METERS
INCREASE NET REVENUE
WRITE FOR DETAILS
BUFFALO METER CO.
2914 MAIN STREET
BUFFALO 14, NEW YORK


ANCHORED CLAMP for MECHANICAL JOINTS
Also CI-60 charcoal cast iron bolts for mechanical joints; bell-joint Leak Clamps and Gasket Sealer Compound.
Write for information
H. Y. CARSON COMPANY
1221 Pinson St. Birmingham, Ala.

Service Lines

(Continued from page 93 P&R)

A new line-operated pH meter that offers high accuracy, simplicity of operation, and unusually low cost is the claim of Bul. 225, distributed by Photovolt Corp., 95 Madison Ave., New York 16, N.Y. A feature of the unit is the replaceable plug-in amplifier unit, hermetically sealed to avoid interference from the effects of humidity.

"Boiler Feedwater Treatment," a 20-page illustrated bulletin, BFT-11, issued by Hungerford & Terry, Inc., Clayton, N.J., features ion exchange softeners, demineralizers, silica removers, and other units for boiler water treatment. Photographs of plant installations and both detailed and block diagrams illustrate the procedures. Deoiling filters, mentioned in the bulletin, are also the subject of a separate folder, D-F, which is devoted to a filter system for purifying oil-contaminated steam condensate for reuse.

A fluoridation nomogram that relates rate of flow and desired fluoride dosage to the required quantity of the commonest fluoride-bearing chemicals has been issued by Proportioneers, Inc., as Keep Sheet No. 24. Copies may be obtained from the company, or B-I-F Industries, Inc., 345 Harris Ave., Providence 1, R.I.

Tee connections made under pressure —"hot taps"—are the subject of a paper on the serious stress conditions produced by such connections in high pressure pipelines, such as are commonly used for oil and gas transmission. Reprints are available as Bul. 533 from Taylor Forge & Pipe Works, Box 485, Chicago 90, Ill.

Johns-Manville industrial products are the subject of a 40-page illustrated catalog devoted to asbestos-cement pipe, insulating materials, packings and gaskets, and other insulating and construction materials. Copies may be obtained from the company at 22 E. 40th St., New York 16.

(Continued on page 96 P&R)

GENERAL FILTER'S

case history files

WILL HELP YOU SOLVE

ANY *water conditioning* PROBLEM

Granted . . . no two water treatment problems are ever exactly alike. Every installation requires individual, specialized attention . . . the composition of the water, rate of flow, local conditions and desired results must all be studied before recommendations are made. However, our authentic case history files of thousands of different installations may cover many of the problems you encounter. A problem that is new to you may be old to us. Save valuable time by checking with General Filter Company first on your water treatment problems. There's no obligation and we'll be glad to give you all the help we can. Write us today!

General Filter Company

AMES, IOWA

. . . better water

write for these FREE booklets today!

GENERAL FILTER COMPANY
DEPT. 00000, AMES, IOWA

Gentlemen: Please send us further information on the subjects checked below:

- ☐ AERATORS
- ☐ FILTERS
- ☐ TASTE AND ODOR
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- ☐ HAVE ENGINEER CALL
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NAME _____ TITLE _____

FIRM _____

ADDRESS _____

CITY _____ ZONE _____ STATE _____

Service Lines

(Continued from page 94 P&R)

A grease seal for centrifugal pumps which automatically supplies the shaft packing gland with grease under pressure is described in a leaflet distributed by Zimmer & Francescon, Moline, Ill. A glass cylinder is filled with the grease and connected at one end to the grease or water seal hole of the packing gland, at the other to the air vent. Differential pressure feeds the grease automatically while the pump is running.

Dust collectors for dry chemical feeding are described in a folder, No. TP-2-M, offered by Wallace & Tiernan, Inc., 25 Main St., Belleville, N.J. There are two models—a floor mounted unit which collects dust in a pail, and a hopper mounted model which returns dust to the hopper. Cloth filter tubes provide 60 sq ft of filtering area and are easily agitated for cleaning without opening the collector.

Pneumatic conveying of dry, powdered, or granular chemicals and other materials by the Vacuveyor is the subject of a leaflet circulated by Vacu-Blast Co., Box 885–R, Belmont, Calif.

"Equipment for Industry," a catalog available from the Advertising & Sales Promotion Dept. of Worthington Corp., Harrison, N. J., contains 16 pages of information about boiler feedwater conditioning equipment, centrifugal and rotary pumps, and other products.

A water reference file dealing with domestic softening has been prepared by Dow Chemical Co., Midland, Mich., and contains reprints of articles and other material on the advantages of home water softening. The file is primarily intended for distribution to home economists, and it is planned to add new material from time to time.

the
MODERN
approach
Cast iron pipe centrifugally cast and with mechnical joints is the most efficient and economical means of modern day disribution. Serving the industry with Super de Lavaud cast iron pipe centrifugally cast in modern long lengths with standardized Mechanical Joints, Bell and Spigot or Flanged, with or without centrifugally applied cement lining. Rugged, dependable and economical.
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ALABAMA PIPE COMPANY
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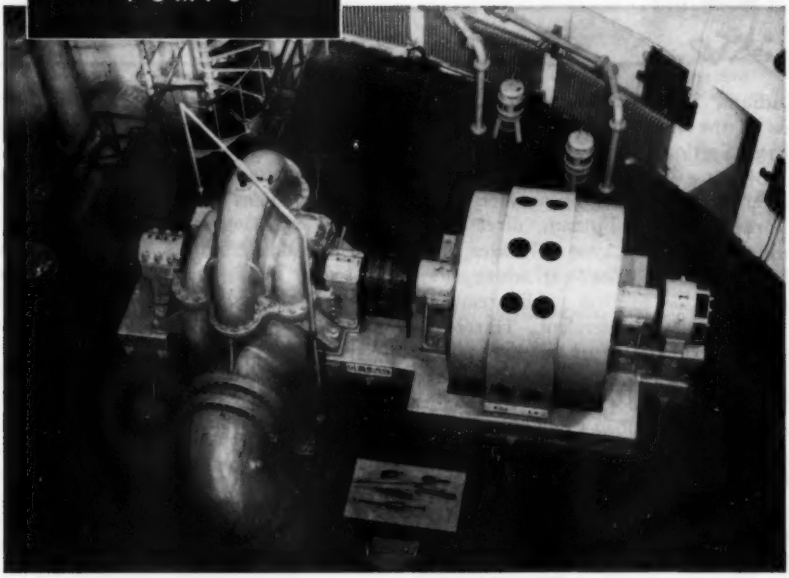
PUMPS

help Louisville meet increased water demand



This 60 mgd, 200-foot head centrifugal pump is one of a group of De Laval units that help meet Louisville's expanding water needs. Today, this growing community is served by De Laval pumps with a total capacity of 314 million gallons per day.

Progressive Louisville, like 80% of America's largest cities, depends on De Laval to meet its ever-increasing pumping demands efficiently and economically for years to come. Such proven dependability is the result of over 50 years experience in pump building, during which time De Laval has perfected and introduced numerous "firsts" in pump design.

De Laval Centrifugal Pumps are available in capacities ranging from 100 thousand gallons per day to more than 100 million gallons per day . . . all built for long, dependable service.

DE LAVAL *Centrifugal Pumps*

DE LAVAL STEAM TURBINE COMPANY
822 Nottingham Way, Trenton 2, New Jersey

DL212A

Section Meetings

Indiana Section: The technical sessions of the 46th annual meeting of the Indiana Section got under way promptly at 1:45 PM on February 10, when Chairman Herbert F. Zinsmeister called for order. A. O. Putnam, director of public relations for Layne & Bowler, Inc., at Memphis, Tenn., used caricature slides to illustrate his talk on public relations for the water superintendent. Harold L. Londo, superintendent of the Green Bay, Wis., Water Dept., discussed water works safety. Reporting for the Water Main Extension Policy Committee, A. O. Norris outlined the conditions of free main extensions agreed upon by his committee and told of some of the difficulties experienced in trying to get them accepted by the Public Service Commission.

On Thursday morning two concurrent sessions were held. In the purification section, B. A. Poole, Technical Secretary of the Indiana Stream Pollution Control Board, gave a progress report of the activities of that board in guiding, and occasionally forcing, progress in stream clean-up. "One thousand miles of streams in Indiana have been restored," he said, "but the job is only about two-thirds complete. Protection of our water supplies is a 'must' in the program."

"Millipore filters are not new but their application to water bacteriology is," said S. R. Damon, director of the Bureau of Laboratories, at the State Board of Health, in discussing membrane filters and their use for determining coliform organisms in water samples. S. R. Kin, chief of the Water and Sewage Lab. at the State Board of Health, told of tests which found the membrane filters to be more accurate than normal lactose tube procedures and to compare quite favorably in accuracy with agar plate counts.

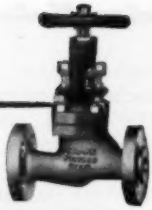
In the general section, Gerald F. Briggs, engineer with Edward E. Johnson, used slides to illustrate a very informative and practical talk on well failures and rehabilitation. A symposium moderated by Lewis S. Finch, chief engineer, Indianapolis Water Co., covered the problem of maintenance for elevated water tanks. Werner Honig, of the Chicago Bridge & Iron Co., outlined the recommended steps of inspection, maintenance, and preparation for paint jobs. F. J. LeFebre, chief engineer, Electro Rust-Proofing Corp., presented the case for cathodic protection. A new application for this part of the country, that of spraying molten zinc on a clean metal surface, was described by S. B. Dent, of Metallizing Engineering Co.

After the business session at the Thursday noon luncheon, Chauncey M. Buck of the Automatic Control Co. resumed the technical papers by discussing the development and use of automatic controls from the earliest—a governor on a steam pump—to the newest equipment available on the market. M. C. Stout, principal assistant engineer, Indianapolis Water Co., discussed the paper by pointing out features of a distribution system which can make either for easy automatic control or difficulty in operation. Earl Carter's paper on continuing property records was read in his absence. It enumerated methods of accounting procedures and the kind of records required by the Public Service Commission. The remarks of R. L. Swingley, treasurer, Indianapolis Water Co., pointed out the value of a continuing property record to management in the way of operating in-

(*Continued on page 100 P&R*)

unmatched in dependability

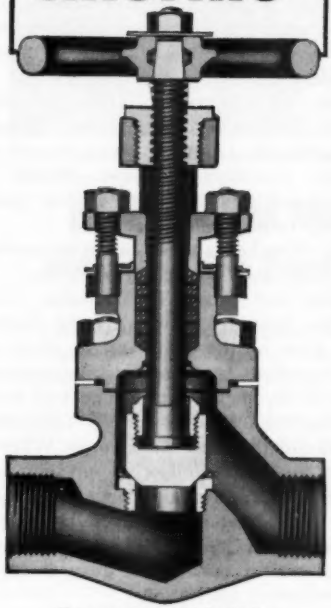
CRANE



Flanged Ends Globe and Angle Patterns

Screwed Ends Globe and Angle Patterns

chlorine valves



Cross-section, Globe Valve with Screwed Ends

now regularly available with screwed ends *and* flanged ends

Take your choice of patterns in these Crane chlorine valves. They're *Crane Quality* throughout—designed exclusively for water-free chlorine gas or liquid up to 300° F.

In the cross-section you can see their strong, rugged construction—and the narrow bearing 45° taper disc and seat design that provides positive closure. Corrosion-resistant materials are used at all critical points. Disc, body seat ring and disc stem ring are durable Hastelloy "C." The stem and the gasket at the leak-proof bonnet joint are Monel. In the extra deep stuffing box there's laminated packing specially developed for chlorine service.

You're better equipped for chlorine control with Crane chlorine valves. Sizes ½ to 2-inch.

FULL FACTS are in new 4-page folder AD 1976. Write direct or ask your Crane Representative next time he calls.

THE BETTER QUALITY...BIGGER VALUE LINE...IN BRASS, STEEL, IRON

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VALVES • FITTINGS • PIPE • PLUMBING • HEATING

Section Meetings

(Continued from page 98 P&R)

formation, cost studies, depreciation, financing, taxes, rates, and insurance.

The Friday morning session used a moving picture on metallizing as an eye-opener, following which Roy D. Smiley of the State Board of Health gave a progress report on fluoridation. After two years of fluoridation in Indianapolis, there are definite trends downward in the D.M.F. rates for six- and seven-year-old school children. In his discussion, George G. Fassnacht of the Engineering Div., State Board of Health, showed that 88 communities in Indiana, serving 42 per cent of the population that uses public water supplies, had water with a natural or standardized fluoride concentration of 0.9 ppm or more.

Harry D. Harman, superintendent of operations, Gary-Hobart Water Corp., presented a very thorough paper on dehumidification of pipe galleries and described the equipment being installed at the new Gary filter plant. Leo Studebaker, chemist at the Hammond Water Plant, closed the technical sessions with his description of results obtained from silica activated in a silactor and used as a coagulant aid.

Dinner sessions were pleasing in every sense. Following the meal Wednesday night, Robert Wilson, vice-president, Indiana Equipment Co., narrated a movie which showed with beautiful photography the tremendous size and engineering complications of the Alcan hydroelectric project in British Columbia.

AWWA President Morrison B. Cunningham discussed Association activities at the Thursday luncheon and tactfully reminded his audience that early work on the use of copper sulfate in water treatment had been carried out in Indiana around 1904 by Dr. Moore. At the business session immediately following this luncheon, there were reports from the various standing committees, and Harvey Wilke, of Purdue University, gave certificates to the water works men who had completed a four-day short course last November. The Nominating Committee report was accepted and the following were elected: Chairman—Harry J. Draves, superintendent, Michigan City Water Utility; Vice-Chairman—George G. Fassnacht, engineer, State Board of Health; Secretary-Treasurer—Robert J. Becker, assistant superintendent of purification, Indianapolis Water Co.

Life Member awards were presented following the banquet to Elmer C. Schwier and James F. Bartuska. The Bradley Award was won by the Southwest Area of the State on the basis of new members and meeting attendance. R. B. Wiley, head of the School of Civil Engineering, Purdue Univ., Lafayette, was nominated for the George Warren Fuller Award. Following presentation of these awards Donald Bruce, radio and news commentator, told a chilling story of communist infiltration into high and low places in our social, governmental, and religious institutions.

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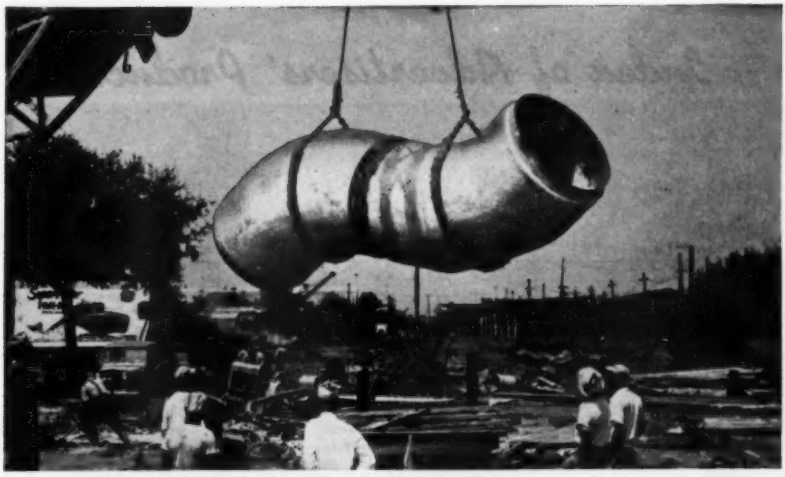


Special curved section of 50-in. ID Bethlehem Pipe being lowered into trench in New Orleans.

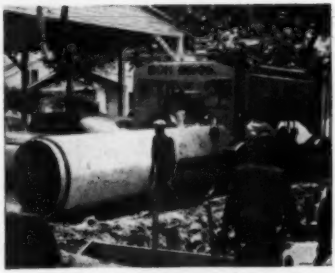
New Orleans Modernizes Water System with 95,000 Feet of Bethlehem Steel Pipe

To meet greatly increased demands caused by the city's tremendous postwar growth, the Water and Sewerage Board of New Orleans has installed almost 18 miles of large-diameter water and sewage lines.

Today, New Orleans boasts nearly 60,000 feet of new 50-in. ID water mains, as well as 35,000 feet of sewage lines in diameters ranging from 24 in. to 50 in. ID. All of this pipe, together with a variety of T's, bends, reducers and flanges, was supplied by Bethlehem.

You'll find Bethlehem Tar-Enameled Pipe ideal for your water and sewage lines. It has great strength, shock-resistance and resilience. And its smooth, uniform lining of coal-tar enamel resists corrosion and incrustation, ensures a high rate of flow year after year. It is furnished in easily-handled 40-ft lengths, and in all diameters from 22 in. ID to the largest permitted by common carriers.

We suggest that you phone or write the nearest Bethlehem sales office for complete information about Bethlehem Tar-Enameled Steel Pipe.



Laying straight section of 50-in. ID pipe. Engineers on the job found the Bethlehem Pipe easy to cut and re-weld when obstructions were encountered.

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On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM *Tar-Enameled* STEEL PIPE

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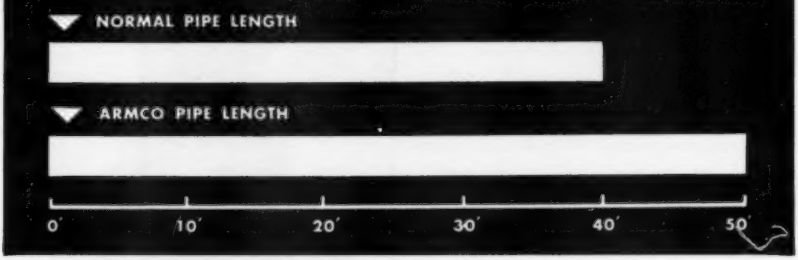
Ross Valve Mfg. Co.
Valves, Swing Check:
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
M. Greenberg's Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.
Waterproofing
Inertol Co., Inc.
Water Softening Plants; see Softeners
Water Supply Contractors:
Layne & Bowler, Inc.
Water Testing Apparatus:
Hellige, Inc.
Wallace & Tiernan Co., Inc.
Water Treatment Plants:
Allis-Chalmers Mfg. Co.
American Well Works
Belco Industrial Equipment Div.
Chain Belt Co.
Chicago Bridge & Iron Co.
Cochrane Corp.
Dorr Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Pittsburgh-Des Moines Steel Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Wallace & Tiernan Co., Inc.
Welsbach Corp., Ozone Processes Div.
Well Drilling Contractors:
Layne & Bowler, Inc.
Well Screens
Johnson, Edward E., Inc.
Wrenches, Ratchet:
Dresser Mfg. Div.
Zeolite; see Ion Exchange Materials

A complete Buyers' Guide to all water works products and services offered by AWWA Associate Members appears in the 1953 AWWA Directory.

"King Size" Pipe

Filters Out High Labor Costs

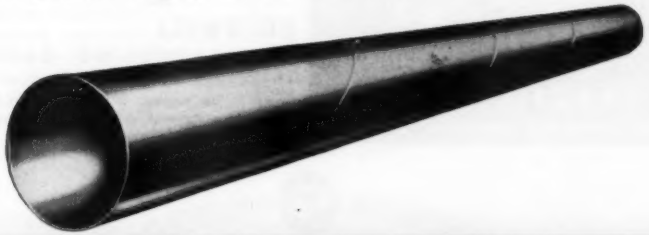


Think of the advantages of using the longer 50-foot sections of Armco Welded Steel Pipe compared to the usual 40-foot lengths. There are fewer sections to haul and handle and 20% fewer joints to make. Labor costs are reduced and installation goes faster.

The wide range of diameters (6 to 36 inches) and wall thicknesses (9/64- to 1/2-inch) makes it easy to match pipe requirements exactly.

Other features of Armco Pipe include ample strength plus ductility, resistance to pressure surges, and the ability to withstand impact of heavy loads without damage. A spun-enamel lining prevents tuberculation. Coatings are supplied to meet A.W.W.A. specifications.

Let Armco Welded Steel Pipe help cut costs of supply lines, force mains or water works piping. Write for complete data. Armco Drainage & Metal Products, Inc., Welded Pipe Sales Division, 2834 Curtis Street, Middletown, Ohio. Subsidiary of Armco Steel Corporation. In Canada: write Guelph, Ontario.



ARMCO WELDED STEEL PIPE

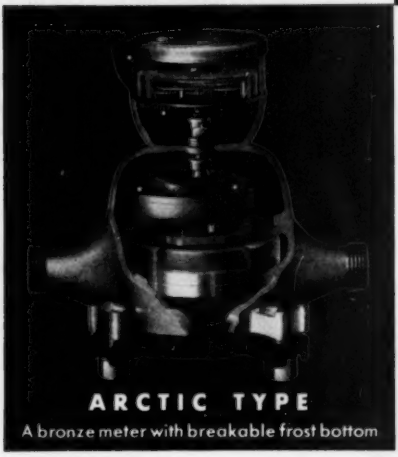
MEETS A.W.W.A. SPECIFICATIONS

ARMCO

How you benefit from the *STAINLESS STEEL TRIM* in all Rockwell Disc Meters

SURE, stainless steel costs more than brass. But we use it freely* in Rockwell disc meters for the corrosion resistance and durability it alone provides. We can afford to offer this extra value only because of our huge production volume. We built this volume by building a better product. Now we can pass on the benefits to you in the form of even superior performing meters —meters that last longer because of this construction and are easy and economical to repair.

TROPIC TYPE
All-bronze, split case construction



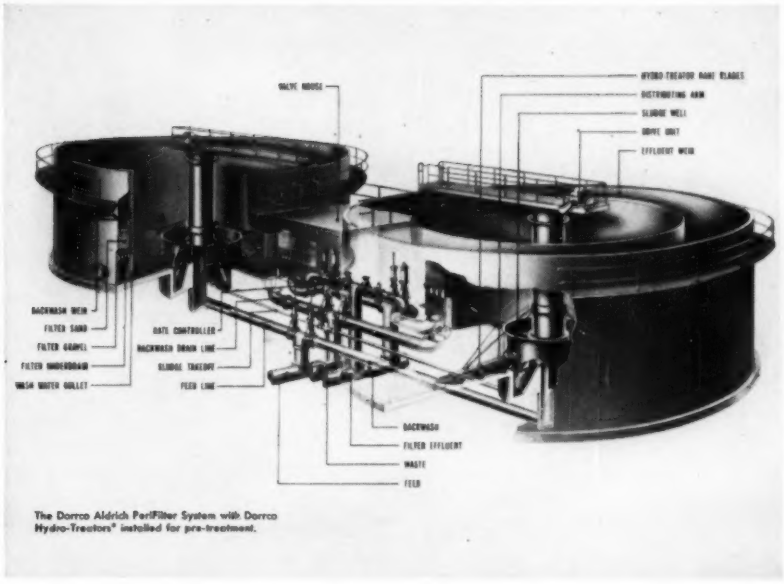
ARCTIC TYPE
A bronze meter with breakable frost bottom

All these Vital Parts Are Made of Stainless Steel:
division plates, driving dogs, disc and stuffing box spindles, screws.

Write for bulletin

ROCKWELL
MANUFACTURING COMPANY
PITTSBURGH 8, PA. Atlanta Boston Chicago
Houston Los Angeles New York N. Kansas City
Philadelphia Pittsburgh San Francisco Seattle Tulsa
In Canada: Peacock Brothers Limited

The Symbol for Service, Quality and Performance in Water Meters



The Dorrco Aldrich PeriFilter System with Dorrco Hydro-Treators® installed for pre-treatment.

New System Cuts Water Filtration Plant Construction Costs Up to 40%

Would you like to realize savings up to 40% in filtration plant construction costs . . . and at the same time get improved operation compared with conventional methods? Both are now possible with the Dorrco Aldrich PeriFilter System. A single PeriFilter consists of a Dorr pre-treatment mechanism surrounded by an annular rapid sand filter and two or more of these dual units are usually manifolded to form the System.

Here's how the PeriFilter cuts costs . . . A unique design permits installation of both pre-treatment unit and filter in the same tank. Valves and piping are greatly simplified. Reduced head losses and simple operation add up to lower operating costs.

Here's how the PeriFilter improves operation . . . Transfer from pre-treatment unit to filter is over a submerged weir so floc breakup is practically nil. Maximum water depth over the filter eliminates air binding. A variety of pre-treatment mechanisms are available for every water treatment need.

We're sure you'll want more information on this new development in water treatment practice. Bulletin 9042 describing the Dorrco Aldrich PeriFilter System will be sent on request, and a Dorr Engineer will gladly supply you with additional information. THE DORR COMPANY, Stamford, Conn. *In Canada:* 26 St. Clair Ave., E., Toronto 5.

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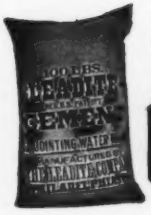
Jointed for . . . Permanence with LEADITE

Generally speaking, most Water Mains are buried beneath the Earth's surface, to be forgotten,—they are to a large extent, laid for permanency. Not only must the pipe itself be dependable and long lived,—but the joints also must be tight, flexible, and long lived,—else leaky joints are apt to cause the great expense of digging up well-paved streets, beautiful parks and estates, etc.

Thus the "jointing material" used for bell and spigot Water Mains MUST BE GOOD,—MUST BE DEPENDABLE,—and that is just why so many Engineers, Water Works Men and Contractors aim to PLAY ABSOLUTELY SAFE, by specifying and using LEADITE.

Time has proven that LEADITE not only makes a tight durable joint,—but that it improves with age.

The pioneer self-caulking material for c. i. pipe.
Tested and used for over 40 years.
Saves at least 75%



THE LEADITE COMPANY
Girard Trust Co. Bldg. Philadelphia, Pa.

No Caulking